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CHAPTER 4

CONCEPTUAL STUDIES AND PRELIMINARY DESIGN

4.1 GENERAL

The project development engineering process begins with a conceptual studies phase. The conceptual studies phase identifies, defines and considers sufficient courses of action (i.e., engineering concepts) to address the transportation needs and deficiencies. The concept definition involves defining the purpose and need for an improvement, the limits of the proposed action in terms of its termini and the extent of its scope. This phase advances a project proposed in the multi-year program to a point where it is sufficiently described, defined and scoped to enable the preliminary design and technical engineering activities to begin. Conceptual studies are typically based on analysis of existing available information, on-site interdisciplinary reviews and meetings with stakeholders. Conceptual studies are typically documented in the form of a project scoping report and in a project agreement.

The preliminary design is the engineering evaluation required, in collaboration with the environmental analysis, to support the decision-making process as described in Chapter 3. This may include developing multiple alignment configurations, roadway templates, pavement structures, roadside features or other alternatives for evaluation. The preliminary design is typically developed to approximately the 30 percent level of design detail using substantial additional information and input than was initially available for conceptual studies, and typically includes identification of a detailed scope of engineering activities and estimated costs for implementing the proposed project and achieving the project objectives on time and within budget. For small-scale improvements, RRR type projects, isolated bridge replacements and other projects constrained by a limited or well defined scope, the conceptual study is simply validation and documentation of the concepts provided from the planning and programming phase. In these cases, the preliminary design and technical engineering activities are readily identifiable and advance directly, in collaboration with the environmental analysis, with limited preceding conceptual study.

A typical process for developing a preliminary design includes:

- develop survey and mapping for preliminary engineering and environmental activities;
- develop design criteria for each alternative being considered;
- develop initial alignments, typical sections and roadway design for each alternative;
- determine proposed pavement structure options;
- develop preliminary technical discipline recommendations, as applicable (e.g., cut/fill slopes, walls, major culverts, bridge foundations);
- develop resource mapping and identify potential impacts of each alternative;

- provide design information for the environmental analysis. This may include such information as areas of impact, preliminary earthwork quantities, waste & staging areas, material source plans, preliminary drainage designs, bridge layout, right-of-way exhibits, construction phasing and closure schedules and cost estimates; and

- provide design information for other analyses such as for Park Roads projects a Value Analysis may be performed by the NPS.

Deliverables or outputs from the preliminary design process may include:

- corridor study report, if applicable;

- preliminary engineering study report;

- 30 percent preliminary plans of the design alternatives (i.e., plan/profile sheets, typical sections, major work items identified and located); and

- preliminary construction cost estimates for the design alternatives.

Conceptual studies and preliminary design are closely related to the environmental process outlined in Chapter 3. The environmental analysis evaluates the engineering proposals resulting from the conceptual studies and preliminary design.

The overall objectives of the conceptual studies and preliminary design are as follows:

- to fully identify and quantify the transportation needs and deficiencies,

- to develop a general course of proposed action, and

- to identify and evaluate with engineering analyses the feasible and reasonable solutions (alternatives) to these needs and deficiencies.

A preferred alternative is identified after the environmental effects of the proposed actions are evaluated in the environmental process/document. Assuming the preferred action includes some form of roadway work, the conceptual study and preliminary design phase concludes with the identification of a selected alternative. The scope of work is defined by a category of improvement, geographical corridor, preliminary highway design standards and clear design concepts. The selected alternative is recorded in the final approved environmental decision document (i.e., Categorical Exclusion, Finding of No Significant Impact, Record of Decision).

Exhibit 4.1-A depicts the general, overall project development process. Specific interdisciplinary activities that are involved in the project development process are not shown, but are addressed in detail in this and other Chapters of this *Manual*. The development of project concepts, the project scoping and preliminary engineering planning, the preliminary engineering development, and the preliminary (i.e., 30 percent) design package for the preferred action are described in this Chapter.

Guidance and references for performing the conceptual studies and preliminary design are described in Section 4.2. The basis for the preliminary engineering investigation is the problem definition and evaluation of existing information that is gathered as described in Section 4.3, together with consideration of the applicable design standards and controls as described in Section 4.4. The result of the preliminary engineering investigation is an initial recommended course of action that is carried forward for development during the preliminary design phase as described in Section 4.6, including any alternatives that will be developed as described in Section 4.7. The results of the preliminary design and alternatives analysis are determined and established as described in Section 4.8. Considerations for implementation of preferred action are described in Section 4.9, and the results of the conceptual study and preliminary design process are documented as described in Section 4.10. Supplemental requirements, guidance and procedures specific to the FLH Division offices are provided in Section 4.11.

The development of the final design is covered in Chapter 9. Additional information on the overall project development process is provided in Chapter 1 of *A Guide for Achieving Flexibility in Highway Design*, AASHTO, 2004.

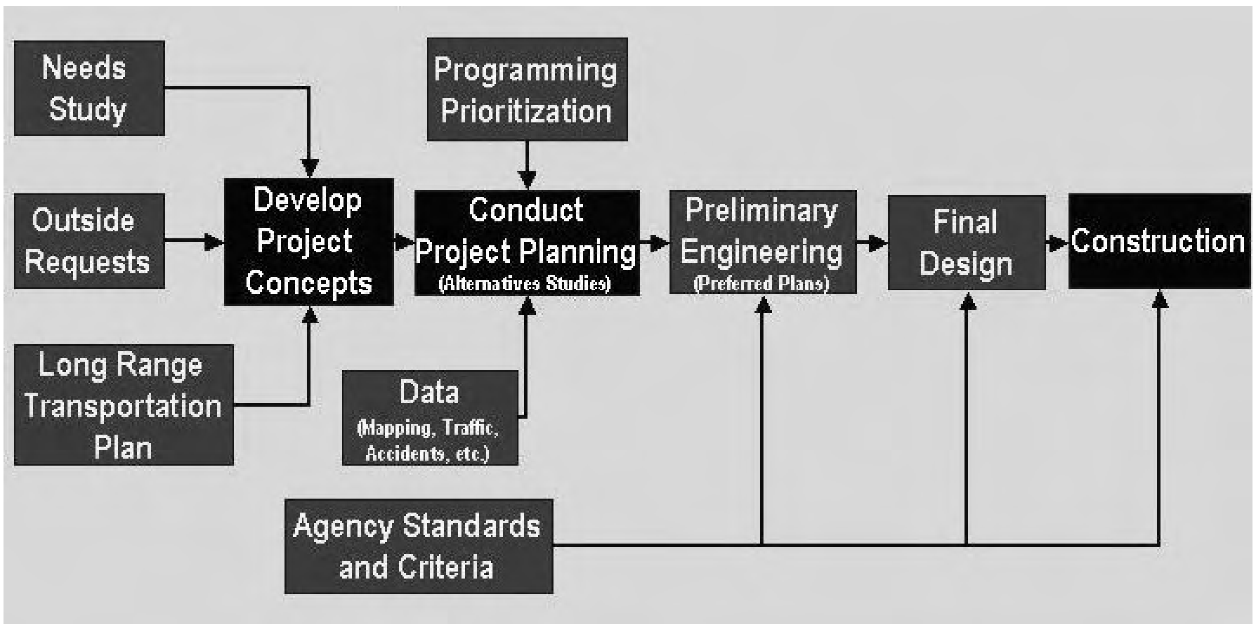


Exhibit 4.1-A PROJECT DEVELOPMENT PROCESS

4.2 GUIDANCE AND REFERENCES

The regulations, policies, guides and references that provide the background for implementing conceptual studies and preliminary design are listed in the various Chapters of this *Manual* relating to the interdisciplinary development of the conceptual studies and preliminary design.

For references on specific subjects, refer to the guidance and references in the appropriate Chapters of this *Manual*. The primary references that are most frequently cited in this Chapter are provided below. The guidance and references are not all inclusive and other documents may contain useful information in special situations.

1. *A Policy on Geometric Design of Highways and Streets,* AASHTO, current edition.

2. *Park Road Standards,* US Department of the Interior, National Park Service, 1984.

3. *A Guide for Achieving Flexibility in Highway Design*, AASHTO, 2004.

4. *NCHRP Report 480, A Guide to Best Practices for Achieving Context Sensitive Solutions*, TRB, 2004.

5. Technical Advisory 5040.28, *Developing Geometric Design Criteria and Processes for NonFreeway RRR Projects*, FHWA, October 17,1988.

4.3 PROBLEM DEFINITION

4.3.1 IDENTIFY PURPOSE AND NEED

Identification of the purpose and need for action begins with an evaluation of the facility's operational, physical and performance characteristics for determination of deficiencies. This includes a comprehensive assessment of its physical condition, safety performance, traffic operational performance, capacity, efficiency, convenience, sustainability, environmental compatibility and maintenance aspects. For new roads, the purpose and need will be established as part of a comprehensive planning study.

A goal or general direction will typically be identified during the planning and programming process. Refer to Chapter 2 for a description of this activity. Development of the purpose and need is an essential activity that is performed as part of the environmental analysis and documentation. Refer to Chapter 3 for additional guidance on development of purpose and need for improvements.

A listing of the road's current deficiencies, both physical and operational, and the relative importance of each should be prepared to indicate where the performance of the road is currently substandard and not functioning properly. Exercise care when determining the major contributing factors of a poorly functioning road facility. Many factors influence and contribute to the performance characteristics of a facility. Do not automatically assume an existing substandard road feature is the problem.

The long-term needs of the users, the facility infrastructure and the surrounding context must also be determined. This is based on projections of how land use activities in an area are going to change along with their associated transportation requirements. A forecasted 20-year ADT and percentage of vehicle types (e.g., trucks, buses, recreational vehicles) that will use the facility is commonly used to describe the future level of use that an improvement is intended to accommodate. Other factors like development of the roadside or of destinations along the route, and functional classification changes also characterize future transportation requirements. The intended lifetime of the improvement and future serviceability must also be determined in order to identify the purpose and need, and to evaluate the level of investment warranted and resulting benefits of various alternative solutions that may be proposed.

4.3.1.1 Interdisciplinary/Interagency Approach

The gathering of existing information and other activities for development of the purpose and need, conceptual studies and preliminary design is performed with an interdisciplinary team, lead by the project manager. Close coordination among the various technical disciplines, especially with the environmental specialist preparing the environmental analysis and documentation, is essential. Various members of an interdisciplinary project team may perform the activities and requirements described in this Chapter, so it is essential that the project team be properly organized with clearly assigned responsibilities to perform each of the various activities that are necessary. It is also essential to maintain close and continuous coordination with the land management agency, and other stakeholders in the facility, during the conceptual studies and preliminary design, as well as throughout the project delivery process.

Since the FLH Program is delivered entirely through partnerships with other agencies, a collaborative approach is used during all phases of the project delivery, with involvement of all stakeholders. The interagency/interdisciplinary approach to conceptual studies and preliminary design is fundamental to obtaining an end product that will serve the public and be consistent with Federal, State and local goals, objectives and standards. Early contact and coordination with partner agencies helps to alleviate or minimize conflict and controversy.

Coordinate with the land management agency contacts and other stakeholders throughout the preliminary and final design process, to achieve a smooth transition between the design and construction phases. The interdisciplinary/interagency study team includes the principle agency contacts for projects that require an environmental assessment or environmental impact study, as described in Chapter 3. Coordinate with contacts of regulatory, resource and other agencies regarding permit requirements and clearances.

On National Park Service projects, the coordinator in the Denver Service Center, or if appropriate, the National Park Service Support Office or the local park representative is the principal contact for input and review of the design alternatives. The NPS will sometimes take the lead for coordination with other agencies and outside disciplines, when applicable.

On Forest Highway projects, the road-owning agency (typically either County or State DOT) engineering staff, and together with engineering staff in the Forest Supervisor's Office and the District Ranger's Office are typically the principal contacts for engineering input. These agencies will normally have technical specialists with local expertise and that are familiar with the transportation needs of the facility, its users and its local context.

On Refuge Road projects, the USFWS regional program coordinator and the refuge facility manager are typically the principal contacts for engineering and technical input. The USFWS will sometimes take the lead for coordination with other agencies and outside disciplines for environmental and permit compliance, when applicable.

On some projects, the FHWA Federal-aid Division office may participate in the development of the project. The extent of the involvement varies from office-to-office, but using the expertise available in the FHWA Federal-aid Division offices can provide an independent review of the preliminary design and environmental analysis.

The project agreement should address the principle contacts, roles and responsibilities for coordination of project delivery activities.

4.3.1.2 Transportation Planning Reports and Inventories

Data collection is an integral step in the conceptual study process. The following Sections describe the most common sources and areas where comprehensive information must be gathered for highway location analysis. Also, general traffic data and operational characteristics including seasonal variations, peak use, vehicle types and their volume percentages should be obtained. Travel information like running speeds, congestion periods or any irregularities should be determined. Typically, the maintenance forces have many observations to offer. The quantity of other road users (e.g., bicyclists, pedestrians) must also be established.

Refer to Chapter 2 for transportation planning reports and inventories that are prepared. Planning reports and inventories are sometimes available from the land management agency or agency with jurisdiction of the highway, in the form of a Needs Study. These documents provide system-wide highway information on the physical condition, current deficiencies and future needs of routes on a system. General types of needed improvements and approximate construction cost estimates may also be documented and can be used to develop a priority list of projects.

While this information is primarily used to show funding needs or assists the priority setting/programming process, it can provide a good starting database for conceptual studies. Usually, needs studies are general in nature and must be expanded and refined into specific project data, issues and details. Comparing the current highway facility with the geometric standards of a road that is sized to accommodate its future traffic volumes and travel conditions can provide an initial indication of the extent of upgrading that may be warranted to address the long-range transportation needs.

4.3.1.3 Information from Land Management Agencies

The land management agencies through their planning offices and area-wide comprehensive planning documents (e.g., NPS General Management Plan, NPS Development Concept Plans, FS National Forest and Resources Management Plans) can provide some information and assistance in determining future travel demands on highways. General management plans and other documents are used to document the land management agencies need to expand facilities or services to other areas, and support the purpose and need for new or improved roads.

4.3.1.4 Response to Emergencies/Site Conditions

Occasionally, a project is developed to repair a damaged road or highway due to an act of nature or a major vehicle incident that made the roadway impassible. These projects were not programmed or planned, but are necessary to keep the roadway open and operational to local and regional traffic. The purpose of this type of project is to simply open the facility as quickly as possible, and will likely not have the benefit of advance planning and coordination to implement all of the desirable improvements, or the available funds to complete much more than restoration to the original condition. Nevertheless, the improvement must not only make the facility open to the public quickly, but it should ensure the reason for the failure is not perpetuated in the reconstruction. Therefore, every effort should be made by the response team to evaluate improvements that will make efficient and effective use of the funds for the roadway system, and make every effort to include other safety enhancements identified through coordination with the land managing agency.

4.3.1.5 Programming Information

Refer to Chapter 2 for programming information that is developed for the project development activities.

4.3.1.5.1 Completed Pre-Programming Studies

Obtain relevant project pre-programming reconnaissance studies and scoping documents, if available (e.g., Project Agreement, Project Identification Report), and relevant scoping reports, conceptual studies and data. Obtain information about the scope of project as established by FLH and partnering agencies and roles and responsibilities of FLH and partnering agencies.

4.3.1.5.2 Project Delivery Schedule

Obtain the proposed project delivery schedule, including the environmental and design schedule milestones, from the Division's project delivery and resource scheduling program (e.g., Program Resource Management System (PRMS), Primavera P3e/c, Open Plan).

4.3.1.5.3 Preliminary Engineering (PE) Budget

Obtain existing information on programmed funding available for preliminary engineering.

4.3.1.5.4 Preliminary Construction Cost Estimate

Obtain any construction estimate information previously developed for the project from any prior conceptual studies and scoping documents (e.g., Project Identification Report, Project Agreement).

4.3.1.5.5 Cross Functional Team (CFT) and Social, Environmental, Economic (SEE) Team Members

Obtain a listing of CFT and SEE team members that are assigned as resources for the project.

4.3.1.6 Preliminary Recommendations for Study

Based on the planning and programming activities, and initial contacts made at the beginning of project development activities, assess information needs and determine how extensive the reconnaissance and preliminary engineering investigation effort needs to be. Before proceeding with subsequent activities covered in this Chapter, develop preliminary recommendations that describe the level of study to be performed during the conceptual and preliminary design. For smaller scale projects, a less comprehensive effort that only requires a limited level of information gathering and reporting may be appropriate for conceptual studies and preliminary design. It may not be necessary to gather all of the existing information listed in the following sections if the scale of planned improvements is very limited.

4.3.2 GATHERING EXISTING INFORMATION

The information on the existing facility provides the historical background and gives an insight as to why the facility was designed the way it exists today. This effort also includes some initial assessments of existing deficiencies. The following subjects are the most common areas where comprehensive information must be gathered before evaluation or analysis can begin for the conceptual studies and preliminary design.

4.3.2.1 As-Built Plans and Previous Studies

Gather relevant information regarding the facility's history, including prior engineering work and previous construction projects, construction reports, etc.

An excellent source of information for reconstruction and RRR projects is as-constructed plans. Each Federal Lands Highway Division office has access to a set of as-constructed plans for its completed projects. They contain information on alignments, drainage, bridges, right-of-way, pavement structure and other engineering features.

Local Government, State DOTs and other Federal land management agencies can also provide as-constructed plans and a variety of information relating to a specific section of highway.

The NPS Denver Service Center maintains microfilm files on as-constructed plans on park road projects. The NPS Regional Offices and individual park units may also have as-built plans, previous engineering studies, or may maintain other information systems that can provide relevant information about the existing facility.

While information from as-constructed plans and from other agencies has significant value, the data should not be blindly accepted as fact. Field verification is necessary.

4.3.2.2 Roadway Geometry

The existing geometric elements of a roadway are used to describe in conventional engineering terms the physical, structural, safety and operational characteristics of a facility. While many elements of design (e.g., stopping sight distance, grades, horizontal/vertical alignment, superelevation) must be established to develop a highway design, only a few controlling elements are essential to evaluate it at the conceptual stage. Roadway width (i.e., lanes, shoulders), design speed, surfacing type and alignment location, or new corridor location, if applicable, are the main criteria for studying highway alternatives.

Other than for new roads entirely on new location, this information consists of an inventory of the physical features and operational characteristics of the existing highway. Most of this information is available from the highway owning agencies (e.g., highway departments, Federal land management agencies), through their road monitoring reports and planning/inventory studies. In addition to as-constructed plans and these reports, the engineer should determine and verify through field inspections the road's length, width, surfacing type, traffic control devices and roadside features along with their current condition. Evaluate the available sight distance along the roadway and at intersections, and identify any discernible sight distance restrictions. For assistance on how to gather this information, refer to Chapter 8 for guidance on preparing an Existing Geometric Controlling Features Analysis.

After gathering the data, compare the existing road and its current functional classification, geometric standards, physical condition and present and future travel demand with the highway agency's road standards. If the highway agency has separate RRR geometric standards and design procedures, determine if they apply to the project. The AASHTO *Green Book* geometric standards are broad enough to address most types of roads if there are no other standards that apply.

For RRR projects where the roadway geometry is not changed, completing the Existing Geometric Controlling Features Analysis, described in Chapter 8, is still necessary to verify the design criteria that will be incorporated into the project.

Geometric design standards and criteria that are developed are discussed in Section 4.4.

Exhibits 4.3-A, 4.3-B and 4.3-C provide illustrations of typical rural cross section elements, typical urban cross section elements and a recoverable front slope including clear zone.

4.3.2.3 Traffic Characteristics

Traffic characteristics play a major role in establishing the concept and design of a highway. Traffic indicates the type of service for which the improvement is being made and directly affects the geometric features of design (e.g., widths, alignment, grades).

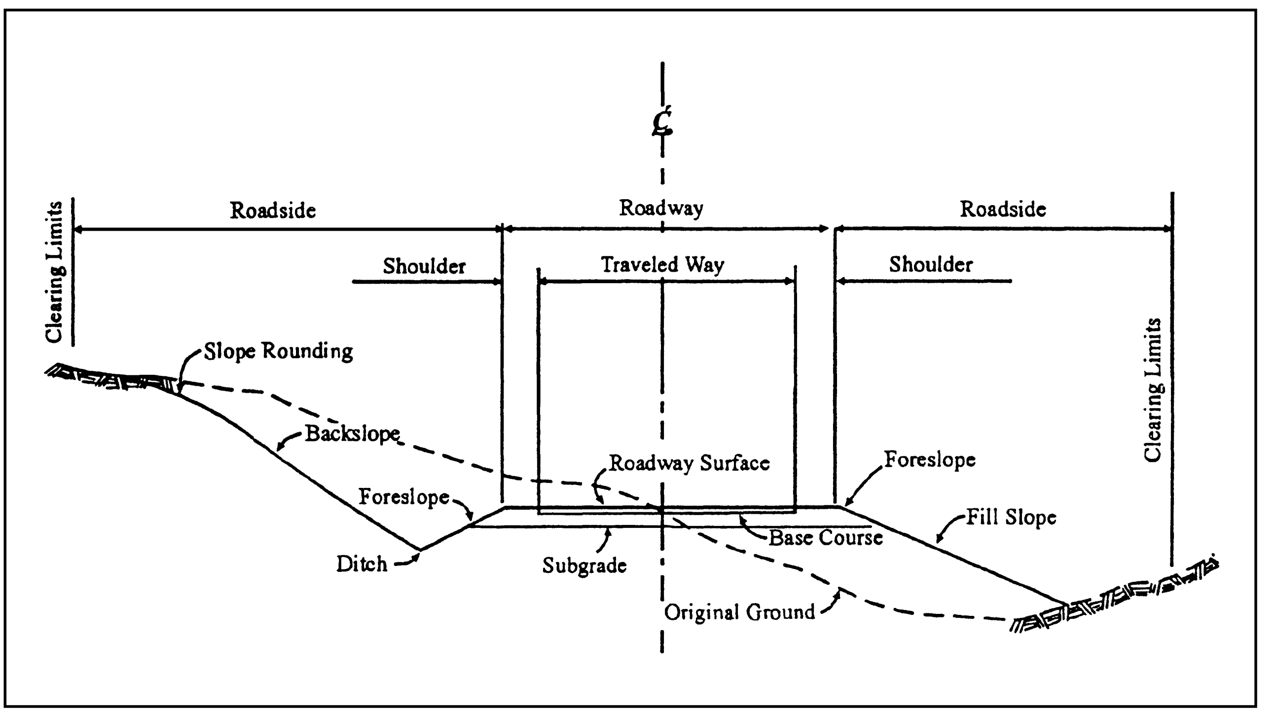
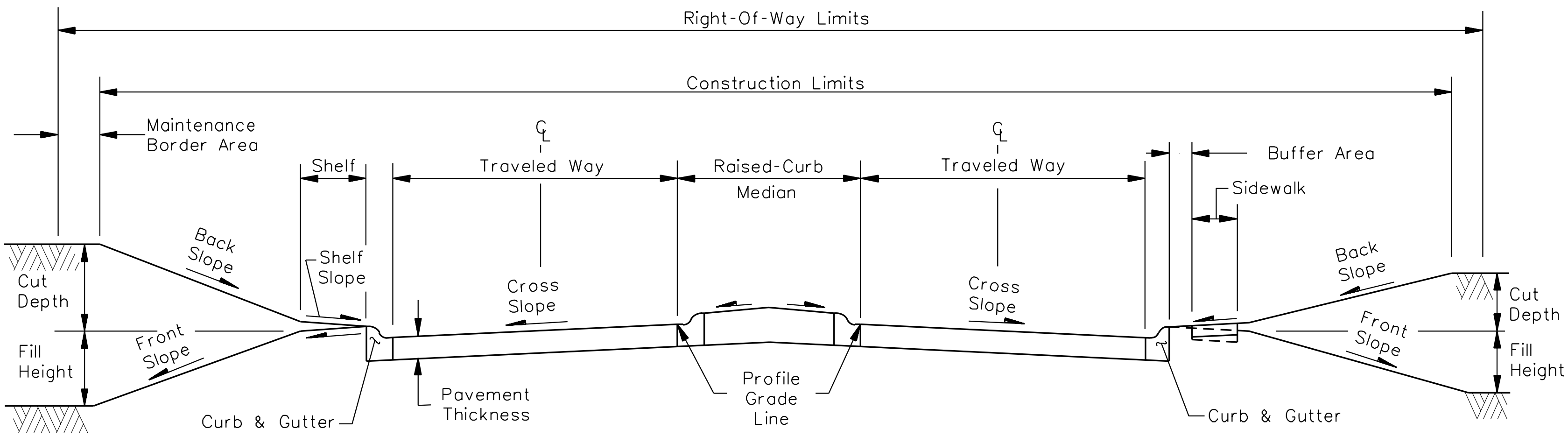


Exhibit 4.3-A TYPICAL RURAL CROSS SECTION ELEMENTS

Exhibit 4.3-B TYPICAL URBAN CROSS SECTION ELEMENTS



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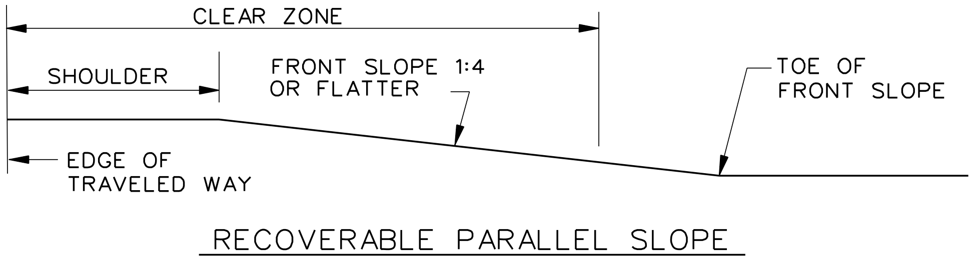


Exhibit 4.3-C RECOVERABLE FRONT SLOPE

General traffic data (e.g., average daily traffic, vehicle classification) is collected on almost a continuous basis by most highway departments and some land management agencies, including the National Park Service. This information can be readily obtained and provides a benchmark for traffic data in the study area. When traffic data is not present, it must be developed by special counts or by calculating the number of vehicles from related information (e.g., National Park visitations, cubic meters (board feet) of timber hauled, recreational visitor days). The FLH Divisions have traffic counter equipment that can be used to collect current traffic data for development of individual projects. When needed to verify the functional classification or other design controls, obtain information on the various user's origin and destination patterns and their functional use of the highway.

Some of the common traffic data elements are listed below, and are better described in Chapter 8. Note that not all items listed are required for every project and can vary depending on specific project requirements:

- average daily traffic;
- seasonal average daily traffic;
- peak and design hourly volumes;
- design hourly volumes;
- traffic trends, past and projected;
- classification of vehicles (i.e., percent passenger vehicles, trucks and buses, recreational vehicles);
- directional split;
- turning movements at major intersections;
- traffic congestion areas;
- speed and delay data; and
- conflict study data.

Identify any areas that are being considered for new traffic patterns, directional signing, revised pavement markings and other changes to traffic control devices that benefit traffic operations.

The AASHTO *Green Book* in Chapter 2, *Traffic Characteristics* provides a description of traffic characteristics (e.g., volume, directional distribution, composition of traffic projections, speeds). While much of this information has a more direct bearing on design details, conceptual studies and associated alternative analyses are also dependent on overall traffic data. Sometimes traffic data (e.g., operating speeds, travel time and delay, occupancy rates) are needed to address a special issue (e.g., determining the design speed or the need for passing lanes). If this data is unavailable, traffic studies as described in ITE's *Transportation and Traffic Engineering Handbook* should be conducted to provide this information.

4.3.2.4 Crash Data

The current traffic crash statistics for the route should be obtained. Vehicular crash data can provide excellent guidance in determining a road's past problems. These statistics are usually maintained and readily available at the highway department, land management agency and/or the law enforcement office responsible for that highway facility. When this type of data is not immediately available, a short-term traffic safety study or an assessment of crash potential should be conducted.

Figures for crash rates are shown in crashes per million vehicle kilometers (miles) traveled. Figures for fatality rates are shown in fatalities per one hundred million vehicle kilometers (miles). Chapter 8 describes in detail how crash rates fit into the safety analyses of highways.

4.3.2.5 Roadside Safety Features

Existing information on roadside features (e.g., clear zone, side slopes, ditch widths, clearing limits, barriers, barrier terminals and transitions, fixed objects) should be identified even if the width of project disturbance will not affect them, as these existing features contribute to the roadside safety as incorporated within the project. (See Exhibit 4.3-A.)

4.3.2.6 Controlling Site Features

In addition to identifying and obtaining information regarding the existing features that are discussed, identify which of these features may control the location or scope of improvements. Identify and obtain information regarding any other features that are not discussed, which will control the location, design or scope of the project.

4.3.2.7 Construction Considerations

Obtain available information on considerations that will control construction activities (e.g., work limitations, access limitations, construction staging and stockpile area limitations, hauling limitations) and limitations on sources of construction materials.

4.3.2.8 Environmental Considerations

A highway has wide-ranging effects beyond that of providing traffic service to its users. It is essential that the highway be considered as an element of the total environment. The highway can and should be located and designed to complement its environment and serve as a catalyst to environmental improvement. Obtain relevant information on the context of the facility and the needs of non-highway users that are affected by the facility, as well as the users. Obtain relevant information on travel destinations and access needs served by the facility (e.g., recreation access within the corridor) and the relationship of the facility within the overall environment.

As applicable, obtain information regarding need for accommodation for wildlife crossings and fish passage within the highway corridor. Refer to Chapter 9, Section 9.5.10 for information regarding design of wildlife crossings and design of drainage structures for fish passage.

Obtain resource mapping (e.g., wetland delineation, historic and archeological sites, wildlife habitat areas mapping and restrictions). Obtain resource information from stakeholder, partner and cooperating agencies and incorporate with the engineering mapping information described below.

Obtain relevant environmental documentation from the environmental process. Data for conceptual studies and preliminary design are collected concurrently with the environmental process and each has a major effect on the other. As outlined in Chapter 3, close coordination is important to ensure the range of improvement alternatives is established in recognition of overall environmental factors. This allows for an orderly, complete evaluation when determining the preferred improvement alternative. Also, the design of the selected alternative must reflect the limitations and mitigation commitments identified in the environmental phase.

4.3.2.9 Survey and Mapping

Obtain existing information on survey control points, benchmarks and control data regarding datum, coordinate system basis, etc., as described in Chapter 5.

Existing aerial photography and mapping generally provide very valuable and essential data in the study and illustration of highways, roadside features and proposed highway improvements. Detail maps and sometimes mosaic photo composites developed specifically for the highway in the study area are needed in the conceptual study stages when improvements include reconstruction. USGS digital ortho quarter quadrangle maps (DOQQ's), satellite imagery or aerial photographs from other agencies can be obtained that assist in the conceptual studies, especially when more minor improvements are being investigated.

Photogrammetric maps, topographic maps (paper copies or digital raster graphs) and aerial photographs of the area are good references and may be obtained from the following sources:

- previous route surveys and reports;
- previous highway corridor mapping;
- maps by Federal, State, county and municipal agencies;

- topographic maps by US Geological Survey (USGS) and National Geodetic Survey;
- hydrographic surveys of rivers and river and harbor surveys by the US Army Corps of Engineers (USACE);
- tideland maps by the State land department;
- surveys by the Bureau of Reclamation, NPS and Bureau of Indian Affairs (BIA);
- highway right-of-way maps by FHWA, State and county agencies;
- Public Land Survey System (PLSS) plats and Master Title Plats from the Bureau of Land Management (BLM);
- maps by Forest Service (e.g., transportation maps, firemen's maps, topographic maps);
- stereo-photographs from private sources and government agencies, particularly the USGS and the Department of Agriculture;
- railway maps and profiles;
- maps made by the State planning divisions (i.e., county maps showing county road systems and roadside culture and city maps, which include the immediate surrounding area);
- FLMA, State and local GIS mapping; and
- county tax maps.

4.3.2.10 Right-of-Way

Collect existing right-of-way documents, plats and exhibits. Obtain existing information regarding railroad property, if applicable. See Chapter 5 and Chapter 12 for right-of-way information gathering.

4.3.2.11 Existing Access Management

Collect existing access management plans and documents, travel management maps, corridor travel management plans, etc., if available.

4.3.2.12 Utilities

Collect existing utility maps, plans and agreements. See Chapter 5 and Chapter 12 for utilities information gathering. Contact the utility company to determine the type and location of existing utilities. Utilities may be located within easements granted specifically for the utility.

4.3.2.13 Permits

Obtain existing use permits for activities within the corridor. Refer to Chapter 3 for information on environmental related permits. See Chapter 12 for Special Use Permits. Utilities typically are within the right of way by permission from the highway owner or operating agency. Permits differ from easements or fee title in that permits are revocable.

4.3.2.14 Geotechnical

Obtain existing geotechnical and materials reports, if available. Obtain geological maps, references and reports for the area. Refer to Chapter 6 for geotechnical information gathering.

4.3.2.15 Pavements

Obtain existing information on surfacing conditions, if available. Refer to Chapter 11 for pavement information gathering.

A useful source of pavement condition data for National Park Service (NPS) roads and parkways is the Road Inventory Program (RIP). The VisiData software application is available to view and query RIP data. VisiData displays forward-view and pavement-view digital imagery, as well as surface condition data and an asset inventory of each paved NPS road.

4.3.2.16 Hydrology and Hydraulics

Obtain available hydrology and hydraulic information where water resources are an issue affecting the road project (e.g., flood plains, erosion, drainage, water quality). This data aids in determining the cause of some road problems and, more importantly, provides guidance to determine feasibility, location or size of hydraulic structures for the alternatives under consideration. This data is needed to establish baseline conditions, address environmental concerns and to resolve engineering design problems, in the preliminary and final design phase. See Chapter 7 for obtaining detailed information about hydrology and hydraulic conditions.

4.3.2.17 Structures

Obtain bridge inventory and condition inspection reports. Obtain existing reports regarding pier, abutment or channel scour. Obtain as-constructed plans of existing bridge structures.

4.3.2.18 Pedestrian and Bicycle Use

Obtain information on pedestrian and bicycle use. Also obtain information on any other motorized and non-motorized use of the facility (e.g., equestrian, snowmobile, all terrain vehicles).

4.3.2.19 Alternative Transportation Elements

Obtain existing information (not performance of new planning or design) pertaining to alternative transportation elements (e.g., transit systems, school busing, tour busing).

4.3.2.20 Intelligent Transportation System (ITS) Elements

Obtain existing information on any ITS systems that are present.

4.4 DESIGN STANDARDS

Geometric design standards relate to the functional classification of highways, traffic density and character, design speed, capacity, safety, terrain and land use.

Design of the overall highway should be done to a consistent standard. Evaluate the route between major termini to maintain a uniform approach to the major design features of an overall route that may be improved in stages on a project-by-project basis.

Proposed highway improvement alternatives are principally described by preliminary design standards. The design standards listed in *FLHM* 3-C-1 (see Exhibit 4.4-A) can be supplemented or substituted with approved highway design standards from owner agencies. Any substitutions of design standards must be consistent with the highway program legislation, regulations and interagency agreements discussed in Chapter 2, Section 2.3 and Section 2.4. Refer to interagency memorandums of agreement for information regarding applicable design standards.

Current guidelines for geometric design emphasize balancing the needs of the transportation user with the context of the facility. This requires a comprehensive understanding of social, economic, and environmental concerns and effects, as well as the concerns and effects for volume, speed, safety and efficiency. Achieving an appropriate balance of the needs of the transportation facility users with values of the environment and communities that are affected involves seeking *Context Sensitive Solutions* (CSS) and applying innovative decision-making approaches to the project development, design and delivery process. Refer to NCHRP Report 480, *A Guide to Best Practices for Achieving Context Sensitive Solutions* for additional information on CSS. Also, refer to Section 4.4.5 and Section 4.7.2 for guidance on CSS.

FHWA has adopted policies and standards for Federal-aid highway design that recognize these concepts and which are also applicable to Federal Lands Highway design. They are listed in Title 23 of the Code of Federal Regulations, Part 625 (23 CFR 625) and supplemented in the *Federal-aid Policy Guide* (*FAPG*). These standards basically adopt AASHTO policy for projects on the National Highway System (NHS) and refer to the approved State or local design guidelines, standards and procedures for non-NHS projects.

Some Federal agencies, most States and many local highway agencies have established standards that adopt AASHTO policy supplemented with additional and clarifying criteria. The designer should be familiar with the sources of information on the design policies, standards, guidelines and procedures that are applicable to the State in which the project is located. See the list of State DOT design manuals.

4.4.1 APPLICABLE DESIGN STANDARDS

It is FLH policy to use approved standards for the design of projects funded from the highway trust fund. For projects funded through owner-agency appropriations, the owner-agency's standards apply, provided they are consistent with professional engineering practice and FHWA and FLH policies, the FLH standard practices outlined in this *Manual* including guidelines for providing context sensitive solutions.

Type of Roadway	Applicable Standards
Forest Highway and Public Lands Highways	23 CFR 625 listed standards and FHWA approved State or local standards
National Park Roads and Parkways	*Park Road Standards* (1984) and 23 CFR 625 listed standards
Indian Reservation Roads	25 CFR 170, *BIA Design Manual* and 23 CFR 625 listed standards
FAA Roads	23 CFR 625 listed standards
BLM Access Roads	*FAPG G6090.13* and *BLM Manual*, Section 9113 – Roads
Defense Access Roads	23 CFR 625 listed standards or FHWA-approved State or local standards
FS Roads and Trails	*FS Handbook* (FSH 7709.56)
ERFO	Standards determined by classification of highway to be repaired or reconstructed. (See *ERFO Manual*)
Refuge Roads	23 CFR 625 listed standards as applicable to RRR projects
US Virgin Islands	23 CFR 625 listed standards and FHWA approved standards (AASHTO Green Book)

Note: *Where there is a conflict between agency standards and 23 CFR 625, the design criteria should be mutually resolved with the client agency.*

Exhibit 4.4-A DESIGN STANDARDS

Exhibit 4.4-A lists the principle FLH Programs and corresponding design standards. The appropriate standards are normally identified from the source of program funding for the project and the associated MOU's as described in Chapter 2. Occasionally the designer will need to determine which standards are approved for use on a specific project. When it is uncertain which standards apply, the Division Project Development Engineer or Design Engineer should be consulted.

When it is determined that specific design criteria are applicable to the particular project type and conditions, then the applicable design criteria is established as the standard for the project. In addition to meeting the minimum design standards, each project should be evaluated on the basis of desirable design criteria to provide the safest overall design.

The AASHTO publication, *A Policy on Geometric Design of Highways and Streets*, (also known as the *Green Book*) is specifically referenced in 23 CFR Part 625 and is the principle source for highway design standards and criteria. Supplements to the *Green Book* include other AASHTO and technical publications adopted by FHWA as acceptable criteria and other approved Federal, State and local specifications for use on their roads. These acceptable supplements are referenced throughout this *Manual*.

While, in many cases, the minimum AASHTO geometric standards will provide the most appropriate level of safety, convenience and operational efficiency, alternatives with different standards must also be considered to address special factors (e.g., economic, environmental, operational) that affect the road, its users and context. Gathering and evaluating diverse land use, transportation, environmental and economic data, together with applied engineering judgment and analysis, will aid in formulating practical improvement alternatives that may fall above and/or below the minimum AASHTO geometric standards.

Environmental impacts and concerns, social impacts, extraordinary costs or costs prohibitive of the limited available funds occasionally justify the need for design elements that are less than the minimum design standard. This is often the case for RRR projects. Analysis should include consideration of adjacent highway sections and the relationship to future improvements, as well as existing conditions, and operational and safety conditions that will result from completion of the project. When the analysis concludes that achieving full standards is not practical, evaluate the consequences and document each decision for exception to the standards as outlined in Chapter 9, Section 9.1.3. The design exception analysis and documentation process shall also include and cover the incorporation in the design any existing substandard conditions or elements that are not reconstructed to approved, current standards as part of the project.

The preliminary design standards, applicable to describe the alternatives being considered, establish further criteria to be used in the final design process. Many of these other elements are functions of the ADT, design speed or roadway width and are developed during the final design phase. The design criteria is typically represented by a range of acceptable values from which a selection is based on the discretion and engineering judgment of the design team to best fit the conditions and a variety of competing objectives. The preliminary design standards, as well as the other design standards and criteria, become the adopted project standards when an alternative is selected in the final approved environmental document (see Chapter 3).

4.4.2 DESIGN STANDARDS FOR RESURFACING, RESTORATION AND REHABILITATION (RRR) PROJECTS

The design policy for RRR projects is the same as for full construction, unless a separate FHWA approved State or local RRR design policy is applicable to the project. However, designing RRR programmed projects to full standards is usually not intended and may not be possible. The RRR design process often includes incorporation into the design many existing substandard conditions or elements that are not reconstructed to approved, current standards as part of the project. Identify all such substandard features and document each exception to the standards as outlined in Chapter 9, Section 9.1.3.

Funding limitations and other factors often prevent designing RRR projects to meet approved standards. Most of the State DOT's have established separate RRR design standards and procedures, which have received FHWA approval for use on their Federal-aid projects. The State's approved RRR design standards and procedures may be used for specific programs or projects where appropriate, such as for Forest Highway and Public Lands Highways, and Defense Access Roads. Before using otherwise approved State or local RRR design standards and procedures for a project, the Division Project Development Engineer or Design Engineer should be consulted.

FHWA has issued guidance to the States for developing specific RRR design standards and procedures, and this guidance is appropriate for use in developing FLH RRR projects, as an exception to the listed standards. FHWA Technical Advisory T 5040.28 provides guidance for developing safety conscious design procedures for the design of RRR projects. For RRR projects, any deviations from the established design standards (e.g., design criteria associated with the posted speed) are treated as design exceptions. This requirement also pertains to the roadside design, and while not included in the 13 principal design elements classified as controlling criteria requiring a formal design exception, it must be fully documented if approved roadside design criteria are not possible to provide. Although deviations from the 13 controlling criteria require approval and documentation as a formal design exception, all deviations from FLH Standard Practices need to receive endorsement and be documented in some manner regardless if for a RRR or a reconstruction project.

For RRR projects, the original roadway template is, at best, restored or slightly enhanced and the geometry (alignment, width, profile) of the facility remains essentially as it was originally constructed. If the surface condition has greatly deteriorated, improvements to the roadway surface may result in slightly increased operating speeds. At some locations the roadway may have deteriorated to a point that the original design template cannot be easily restored. In some locations the existing geometry, and its inferred theoretical design speed as categorized by current geometric standards, will often be less than the current design standards for the posted speed limit. Although the original geometry and its associated design criteria is perpetuated by the RRR project, the project should assume a new overall design speed that is consistent with the posted speed limit that will be established after the project is completed (or a higher speed if justified). Although a facility's as-constructed plans may indicate or theoretically infer an original design speed, it should not ordinarily be perpetuated as the design standard for the new project if it is less than the posted speed limit. There may be certain instances (such as where the theoretical design speeds of curves are consistently 16 km/h (10 mph) lower than the posted speed) where the posted speed should be re-evaluated.

Some RRR projects cannot be surveyed cost effectively in enough detail to determine existing design values, or identify many of the exceptions to the controlling criteria (e.g., superelevation, grades). These projects place considerable emphasis on the awareness and engineering judgment of the designer to recognize and document substandard conditions.

Chapter 8 describes techniques to evaluate safety conditions and deficiencies applicable to RRR projects. Additional considerations for the evaluation of lesser design conditions are provided in Chapter 3 (pages 49-80) of AASHTO *A Guide for Achieving Flexibility in Highway Design*, May 2004; and on pages 190-206 of *TRB Special Report 214, Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation*, 1987.

Refer to Chapter 9, Section 9.4 for additional design guidance specific to RRR projects.

4.4.3 GEOMETRIC DESIGN

Geometric design is the development of the surface dimensions of a highway such that its form will meet the functional and operational characteristics of drivers, vehicles, pedestrians and other users. The geometric design includes the facility's location, alignment, profile, cross section, intersections and shape of the roadside. The geometric form and dimensions should reflect the user's desires and expectations for safety, mobility, comfort, convenience and aesthetic quality. It should do so with compatibility and sensitivity to the terrain, land use, roadside and community development, natural and cultural environment, and with consideration for cost and economic efficiency. A consistent approach to geometric design matches and reinforces expectations of the user, which is important to guide the full range of drivers and conditions including drivers that are unfamiliar, older, inexperienced, distracted, inattentive, tired or impaired. A consistent approach also addresses the safety and other needs of pedestrians and bicyclists, and their interactions with motor vehicles. See Chapter 9, Section 9.3 for guidance and philosophy on development of the geometric design.

4.4.4 DESIGN CONTROLS

To establish the preliminary geometric design standards of roadway width and design speed, it is necessary to know the functional classification of the route, the predominate terrain (i.e., level, rolling, mountainous) within the corridor, the location (i.e., rural, urban), the traffic volumes (i.e., current/future ADT) and speeds of the highway, user characteristics and other factors. The following Sections address the specific design controls.

4.4.4.1 Functional Classification

The AASHTO *Green Book* establishes a relationship between functional classification and design criteria (refer to Chapter 1 §Functional System Characteristics). Also refer to FHWA functional classification guidelines. The functional classification of a particular highway establishes a range of design speeds, and together with the selected design speed further defines a range of parameters associated with horizontal and vertical alignment, lane width, shoulder type and width, type and width of median area and other major design features.

The functional classification of the project will normally be determined during the planning and programming phase, and it is verified with consideration of additional data as part of the conceptual engineering studies. Determine the functional classification from a statewide perspective not simply a "forest," "county" or tribal reservation point of view. For NPS projects refer to the Park Road Standards functional classification below. Some Forest Highways and IRR roads may fulfill a relatively high function within their respective area; however, the functional classification should be from the point of view of roads in the State. Many State DOTs maintain maps indicating the functional classification of all roads in that State.

4.4.4.1.1 Local Roads

Local roads primarily provide access to adjacent land with little through movement. Very few FLH projects are located on routes with local road functional classification. Some Refuge Road projects, IRR projects and ERFO projects are located on local roads.

4.4.4.1.2 Collectors

Collectors provide a medium level of service at moderate speed for intermediate distances by collecting traffic from local roads and connecting them with arterials. Many FLH Forest Highway and Public Lands projects are located on routes with collector classification.

4.4.4.1.3 Arterials

Arterial roads provide a high level of service at high speeds for relatively long distances, with little interruption and with some degree of access control. Some FLH projects, and a number of special projects, are located on routes with arterial classification.

4.4.4.1.4 Freeways

Freeways are a type of arterial road that provide full access control, accommodate the highest speeds with no traffic interruption. A few FLH special projects are located on routes with freeway classification.

4.4.4.1.5 National Park Service Roads

The National Park Service, in its 1984 *Park Road Standards*, has established its own system of functional classification. The park road system is grouped into the following categories:

1. **Public Use Park Roads**. All park roads that are intended principally for the use of visitors for access into and within a park or other National Park System area are included. This includes all roads that provide vehicular passage for visitors, or access to such representative park areas (e.g., points of scenic or historic interest, campgrounds, picnic areas, lodge areas). County, State and US numbered highways maintained by the Service are included in this category:

    a. *Class I - Principal Park Road/Rural Parkway*. Roads that constitute the main access route, circulatory tour or thoroughfare for park visitors.

    b. *Class II - Connector Park Road*. Roads that provide access within a park to areas of scenic, scientific, recreational or cultural interest (e.g., overlooks, campgrounds).

    c. *Class III - Special Purpose Park Road*. Roads that provide circulation within public use areas (e.g., campgrounds, picnic areas, visitor center complexes, concessionaire facilities). These roads generally serve low-speed traffic and are often designed for one-way circulation.

d. *Class IV - Primitive Park Road*. Roads that provide circulation through remote areas and/or access to primitive campgrounds and undeveloped areas. These roads frequently have no minimum design standards and their use may be limited to specially equipped (e.g., 4-wheel drive) vehicles.

2. **Administrative Park Roads**. These consist of all public and nonpublic roads intended principally for administrative purposes:

   a. *Class V - Administrative Access Road*. All public roads intended for access to administrative developments or structures (e.g., park offices, maintenance areas, employee residential areas, utility areas).

   b. *Class VI - Restricted Road*. All roads normally closed to the public, including patrol roads, truck trails, fire protection roads and other similar roads.

3. **Urban Parkways and City Streets**. These are generally dual-use facilities in that they serve both park and non-park related purposes:

   a. *Class VII - Urban Parkway*. These facilities serve high volumes of park and non-park related traffic and restricted, limited-access facilities in an urban area. This category of roads primarily encompasses the major parkways that serve as gateways to our nation's capital. Other park roads or portions thereof may be included in this category.

   b. *Class VIII - City Street*. City streets are usually extensions of the adjoining street system that are owned and maintained by the National Park Service. The construction and/or reconstruction should conform with the accepted engineering practice and local conditions.

The assignment of a functional classification to a park road is not based on traffic volumes or design speed, but on the intended use or function of that particular road or route.

4.4.4.2 Topography

The topography of the land has an influence on alignment. AASHTO separates topography into three classifications of terrain:

- level,
- rolling, or
- mountainous.

A description of these three types of terrain is in the *Green Book* in Chapter 3 § Vertical Alignment ~Terrain.

Terrain classifications pertain to the general character of a specific route corridor. For example, routes in mountain valleys and mountain passes that have all the characteristics of level or rolling terrain should be classified as such. The terrain classification determines the maximum allowable grades in relation to design speed.

4.4.4.2.1 Flat Terrain

Overall terrain is generally sloping 1V:20H or less. Sight distances, as provided by horizontal and vertical geometry, are generally long or can be made so without construction difficulty or major expense. Trucks and passenger cars can operate at similar, consistent speeds.

4.4.4.2.2 Rolling Terrain

Overall terrain is generally sloping between 1V:20H and 1V:3H. Natural slopes repeatedly rise and fall below the road grade, and occasional steep excavation and embankment slopes restrict or control the horizontal and vertical alignment. The terrain generates steeper grades than in flat terrain, causing trucks to often operate at speeds below those of passenger cars.

4.4.4.2.3 Mountainous Terrain

Overall terrain is frequently sloping over 1V:3H. Changes in terrain elevation with respect to the roadway cross section and profile are abrupt. Benched side-hill excavation and limited locations for embankments are typical restrictions that control the horizontal and vertical alignment. The terrain generates steep grades causing some trucks to operate at substantially slower speeds than passenger cars.

The AASHTO *Green Book* recognizes the unique difficulty and expense of road construction in mountainous terrain, and for some geometric design elements, it suggests reduced values in the criteria than for other terrain.

4.4.4.3 Location

The *Green Book* categorizes highway functions and design criteria according to rural and urban locations. For planning purposes, location is classified as the following:

1. **Urbanized**. Urbanized areas are large urban areas with forecast population over 50,000.

2. **Small Urban Areas**. These are urban areas with forecast population between 5,000 and 50,000.

3. **Rural**. Rural areas are those areas less with forecast population less than 5,000 and outside the boundaries of urban areas.

Intersections are classified as either at-grade, separated without ramps and interchanges. The *Green Book*, Chapter 9 provides guidance specific to at-grade intersections.

4.4.4.4 Traffic Volume

4.4.4.4.1 Volume Classifications

For determining design criteria, the *Green Book* classifies traffic volume as < 250, < 400, < 1500, < 2000 or > 2000 average daily traffic (ADT).

4.4.4.4.2 Design Hourly Volumes

The design hourly volume (DHV) for rural highways should be the 30th highest hourly volume of the future year chosen for design. The 30th highest hourly volume also applies in general to urban areas; however, where substantial fluctuation in traffic volume occurs other hours may be considered as the basis of design.

4.4.4.4.3 Future Traffic Projections

Traffic projections are typically forecast for a period 20 years ahead of the anticipated completion of the project. Some metropolitan planning organizations have developed traffic projections on various routes for a specific planning horizon year, based on region-wide traffic modeling systems.

4.4.4.5 Design Vehicle

The design vehicle is the controlling vehicle constraint for design of the project. This can be represented as a standard passenger car, motor home, single-unit truck, bus or semi-trailer. The *Green Book*, Chapter 2 § Design Vehicles, describes the parameters of representative design vehicles. The selection of an appropriate design vehicle should be made with knowledge of the existing and anticipated type-of-use, the tradeoffs involved with design and spatial impact, and with input from stakeholders and the public. The selection of a design vehicle should be the largest vehicle that uses the facility on a regular basis, and it should represent a cost-effective choice for the project and be appropriate for its context. The use of the facility by the design vehicle should be a measurable and reasonably predictable percentage of the average daily traffic.

In comparison to some major State highways, FLH Program projects are typically designed with a need to accommodate relatively high-use by recreational vehicles (motor home or passenger car with trailer) or intercity tour busses, and relatively low-use by large semi-trailer trucks.

Commercially available computer software (e.g., AutoTurn) may be used for verifying vehicle tracking paths at intersections, in parking lots, sharp curves, etc., and for developing templates for special design vehicles.

The AASHTO classification parameters represent all vehicles within a particular classification and are summarized in the following:

1. **Passenger Car (P) and Trailers (P/T)**. A passenger car may be selected as the design vehicle when the main traffic generator is parking lot or series of parking lots. A

combination of passenger car and boat trailer or camper trailer should be considered when the parking facilities include such recreational uses.

2. **Motor Home (MH) and Boat Trailer (MH/B)**. A motor home may be selected when the main traffic generator is a recreational facility, such as a park or forest recreational area. A combination of MH and boat trailer should be considered when the recreational facility includes such use.

3. **Single Unit Truck (SU)**. A single unit truck may be used for intersection design of major residential streets, local roads, collectors and park or forest roads that serve visitor concession facilities.

4. **Bus**. An intercity bus (motor coach) may be used for collector roads and minor arterials, and park roads, serving intercity bus routes, tourism destinations, visitor lodging and interpretive facilities, etc. A city transit bus may be used for intersections of urban highways and city streets that are designated city bus routes, and otherwise have relatively few large trucks using them. The large or conventional school bus may be used for intersections of highways with low-volume county highways or very low-volume local roads and for residential subdivision major street intersections.

5. **Semi-trailers (WB)**. The intermediate semi-trailers WB-12 (WB-40) and WB-15 (WB-50) may be used for local or collector roads and minor arterials that serve some level of commercial truck traffic. The interstate semi-trailer WB-19 (WB-65) or WB-20 (WB-67) should be used for intersections of arterial roads and for other intersections on highways and industrialized streets or industrialized local roads that carry either high volumes of traffic or that provides local access for large trucks.

4.4.4.6 User Characteristics

Driver performance and human factors are integral to the determination of highway design criteria. The *Green Book* provides guidance on consideration of the user characteristics in Chapter 2 § Driver Performance. For application of design criteria and design of countermeasures, consider the presence, characteristics and special needs (i.e., information, time, visibility) of the following types of users:

- inexperienced drivers,
- older drivers,
- unfamiliar drivers,
- familiar drivers,
- pedestrians, and
- bicyclists.

Also refer to Chapter 9, Section 9.3.4.1 for discussion of the relationship of human factors to the geometric design.

4.4.4.7 Maximum Superelevation Rate

The maximum superelevation rate considers the climatic conditions (frequency and amount of snow and ice), terrain conditions, type and location of the area, and frequency of very slow moving vehicles whose operation might be affected by high superelevation rates (e.g., trucks, farm machinery). Maximum curvature is a function of the maximum superelevation and the design speed. The *Green Book*, Chapter 3 § Horizontal Alignment ~ General Considerations, provides guidance on selection of maximum superelevation rates. The highest superelevation rate commonly used is 10 percent, although 12 percent is used in rare cases. For FLH projects, 8 percent is the practical maximum superelevation rate that should be used. For areas with snow or ice for extended periods during winter months, the maximum rate should be no more than 6 percent. A maximum superelevation rate of 4 percent is recommended for portions of roads where the predominant traffic operates in snow-packed or icy conditions (e.g., primarily serves winter recreation and ski areas) and for urban streets.

4.4.4.8 Speed Characteristics

Refer to the *Green Book*, Chapter 2 § Traffic Characteristics ~ Speed, for additional guidance.

4.4.4.8.1 Running Speed

The speed at which an individual vehicle travels over a designated section of highway is known as its running speed. The running speed is simply the length of the highway section divided by the elapsed running time for the vehicle to travel the section. The average running speed is the sum of the distances traveled by vehicles on a highway section during a specified time period divided by the sum of their running times. The average running speed of all vehicles is the most appropriate speed measure for evaluating level of service and road user costs. Spot speed measurements of sections of highway that do not vary materially may be used to approximate the running speed.

4.4.4.8.2 Operating Speed

Operating speed is the speed at which drivers are observed operating their vehicles during free-flow conditions (not following). The 85^{th} percentile of the distribution of observed speeds is the most frequently used measure of the operating speed associated with a particular location or geometric feature.

The average speed is the summation of the instantaneous or spot-measured measured speeds at a specific location of the free-flowing vehicles divided by the number of vehicles observed.

The pace speed is the highest speed within a specific range of speeds that represents more vehicles than in any other like range of speed. The range of speeds typically used is 16 km/h (10 mph).

4.4.4.8.3 Posted Speed

The posted speed is the signed and legally enforceable speed limit established by the entity with responsibility for the highway. The regulatory speed is the speed limit applicable to the highway in the absence of a posted speed limit, and is typically established by state or local statute, local ordinances or other regulations. The *MUTCD* typically references the posted speed for design of traffic control devices.

4.4.4.8.4 Design Speed

From the *Green Book*, design speed is a selected speed used to determine the various geometric design features of the roadway. Highway geometric design criteria is typically classified or determined on the basis of the design speed. The primary considerations for selection of the design speed are the posted speed (or 85th percentile operating speed), terrain, traffic and functional classification of the highway. Refer to Section 4.4.4.9 for guidance on selecting an appropriate design speed.

4.4.4.9 Selecting an Appropriate Design Speed

A principle element in establishing design criteria is the selection of the design speed for the facility. **It is FLH policy that the design speed must equal or exceed the posted or regulatory speed limit of the completed facility.** Where an established geometric design standard for the posted or regulatory speed cannot be met, and lesser values are proposed, the condition must be treated as a formal design exception as outlined in Chapter 9, Section 9.1.3. The design exception can cover a single location on the project, multiple locations, or the entire project corridor. Chapter 9, Section 9.1.3 provides guidance on how to evaluate and document geometric design exceptions.

Refer to the *Green Book*, Exhibit 6-1 for recommended design speeds for rural collector roads. For rural arterial roads the *Green Book* recommends design speeds in the range of 60 to 120 km/h (40 to 75 mph). Also refer to Table 1 of the *Park Road Standards* for typical design speeds. When the recommended design speed for the type of facility cannot be achieved, address the situation as a formal design exception.

The selection of an appropriate design/posted speed involves consideration of many factors including the expected usage, operating speeds, access, topography and impacts. To encourage the development of a “self-explaining, self-enforcing” roadway it is FLH Standard Practice to select a design speed that is logical and recognizable to the driver; and that reinforces the driver’s expectations and behavior with respect to the purpose and function of the highway, its location, topography, adjacent land use and intended speed; and that is consistent with other geometric and roadside design features (e.g., lane and shoulder widths, cross section elements). The design speed should be consistent with the speed the driver expects. It should be logical for the topography, adjacent land use and type of highway. The *Green Book*, Chapter 2 § Traffic Characteristics ~ Speed, explains the philosophy of design speed and its relationship to operating speed and running speed. A discussion of design speed is covered in pages 12-13 of the *Park Road Standards*. Recent research on design speed, operating speed and posted speed practices is provided in *NCHRP Report 504* and *Transportation Research Record (TRR) 1796*, 2002.

In most instances, the owner agency has the authority to establish the posted speed for the facility. When necessary, regulatory limits should be recommended to the owner-agency to provide guidance in setting posted speeds that are consistent with the design of the highway. However, when system-wide statutory speed limits prevail they mandate the posted speed.

In order to provide overall design consistency, and to minimize the use of design exceptions, all possible effort should be made to coordinate the proposed design criteria with current standards for the posted speed limit (or higher) through one of the following methods:

- by obtaining agreement with the owning/maintaining agency to establish a posted speed limit that is most consistent with the proposed design,
- by reconstruction of deficient features to meet the posted speed design standards, and
- by a combination of these approaches.

Where the measured 85th percentile operating speed is determined to be significantly higher overall than the posted speed limit (e.g., 16 km/h (10 mph) or more), it is recommended to use a design speed that is higher than the posted speed limit. Posting a speed limit and setting the design speed significantly lower than the overall 85th percentile operating speed may not adequately address substantive safety needs. It has been found that reducing the posted speed limit (e.g., matching with too low of a design speed) will likely have little or no effect on the overall 85th percentile operating speed without adequate enforcement. Inconsistencies and safety risks inherent in the geometric design cannot be corrected or masked simply by changing the posted speed limit, even though the number of formal design exceptions, legal liabilities and need for mitigation of safety risks may be perceived as reduced. Current best practice for speed management is to establish the posted speed limit with strong consideration for the overall measured 85th percentile operating speed. Current best practice for the selection of a design speed is through an iterative process of developing a preliminary design, estimating the overall 85th percentile operating speeds along the alignment, checking for large differences between the 85th percentile speeds on successive curves, and revising the proposed alignment to reduce these differences to acceptable levels. Where revision to the proposed alignment is not feasible (e.g., RRR projects), then mitigation to address the speed differences should be provided.

The design of traffic control devices (e.g., warning signs, no-passing zones) are based on either the 85th percentile operating speed or the posted or statutory speed limit, rather than the design speed.

4.4.4.9.1 Considerations of Speed

Except for local streets, park roads and other recreational roads where speed is not needed or desired, every effort should be made to minimize the time of travel and to use as high a design speed as practical to attain the user's desired degree of mobility, efficiency and safety within the constraints of environmental quality, economics, aesthetics and social or political impacts. The longer the trip, the greater the driver's desire to use higher speeds, therefore knowledge of users' travel distance from trip origin to destination is important. On rural highways, a higher percentage of vehicles are usually able to travel at the limiting speed that is governed by the geometric design, so the selection and relationship of the geometric design elements affecting speed are especially important to optimize. On rural arterials, the driver expectation is to safely operate at higher speeds than for collector and local roads.

4.4.4.9.2 Considerations of Calming/Low-speed Environment

Where conflicts exist between higher speed and lower speed users, pedestrians, bicyclists, wildlife, recreational uses, residential activity, business activity and complex traffic situations, it may be beneficial to provide lower design speed criteria, features and traffic calming measures for reduced speeds, as appropriate. Speed can be reduced by inducing curvature into the alignment, with greater accumulated curvature deflection of the alignment having greater affect. A curvilinear alignment consisting of a series of low-speed curves, with a gradual change in radius between the successive curves, will reinforce the desired low-speed operation. Sudden unexpected changes in the alignment, profile, cross section or roadside elements are not recommended; however, gradual changes over a transition section that is apparent to the driver can be effective to introduce a low-speed operating environment.

Traffic calming measures include features added to the roadway to create horizontal or vertical deflections, a narrower and more constrained cross section, signing, noise, bumps or vibration to increase the driver's awareness of speed. A description of traffic calming techniques is available at the FHWA and the ITE websites.

Additional guidance on traffic calming is provided in Chapter 8 and the Traffic Calming website.

4.4.4.9.3 Managing Variations in Operating Speed

Many vehicles operate at speeds higher than the design speed on long tangents and flatter curves. These vehicles have to slow to the design speed in order to safely and comfortably negotiate the sharpest curves. In areas of sharp curves, the radius and the superelevation of adjacent curves should be designed to limit the difference in operating speed between the curves to a maximum of 20 km/h (15 mph), and preferably, to less than 10 km/h (5 mph). If the maximum differential is exceeded, the plans must include advance curve and advisory speed signs for the lower speed curves. Additional delineation of the lower speed curvature should be considered on a case-by-case basis (e.g., delineators, raised pavement markers, chevrons).

The Interactive Highway Safety Design Model (IHSDM) and its associated references provide methodology to determine the predicted operating speeds for a particular design and horizontal alignment. The IHSDM is currently not calibrated for use with design speeds less than 55 km/h (35 mph). Application of the IHSDM is described in Chapter 8.

Alternatively, the variation in operating speed may be roughly predicted by determining the inferred design speed of the geometry at various locations based on a comparison with the horizontal and vertical design criteria prescribed by the *Green Book* for the various design speeds, and by a correlation of the inferred design speed with observed operating speeds. The speed correlations are described in NCHRP Report 504.

Except for a controlled intersection, do not design the roadway geometry for an operating speed less than 30 km/h (20 mph). For design speeds of 100 km/h (60 mph) or greater, provide a design having highly consistent geometry, and that facilitates vehicle operation at a uniform speed.

Exhibits 4.4-B and C describe maximum variations in operating speed for design consistency.

Also, refer to Chapter 9, Section 9.3.4.2 for additional guidance on the concepts of design consistency.

Maximum Variations in Operating Speed

Condition Status	Design Speed (km/h)		
	< 60	**60 to 90**	**> 90**
Unacceptable	25	30	25
Undesired	15	20	15
Typical	10	<10	5
Desired	5	5	0

Exhibit 4.4-B MAXIMUM VARIATIONS IN OPERATING SPEED BETWEEN SUCCESSIVE CURVES, AND BETWEEN LONG TANGENTS AND CURVES, FOR DESIGN CONSISTENCY (Metric)

Maximum Variations in Operating Speed

Condition Status	Design Speed (mph)		
	< 35	**35 to 55**	**> 55**
Unacceptable	15	20	15
Undesired	10	15	10
Typical	5	<10	<5
Desired	5	5	0

Exhibit 4.4-C MAXIMUM VARIATIONS IN OPERATING SPEED BETWEEN SUCCESSIVE CURVES, AND BETWEEN LONG TANGENTS AND CURVES, FOR DESIGN CONSISTENCY (US Customary)

4.4.4.10 Self-explaining, Self-enforcing Road Concepts

Incorporate self-explaining, self-enforcing road concepts into the conceptual and preliminary design, as appropriate. The concept of the self-explaining, self-enforcing road is that the road (both the roadway and the roadside) is particularly and completely designed for a specific, commonly recognizable, purpose or function. This concept, or philosophy, relies on the physical roadway design attributes to passively "enforce" or reinforce intended operating speeds and other driver behaviors, rather than relying primarily on signs, directives and active enforcement. Conflicting road attributes (e.g., a high-speed cross section combined with a low-speed alignment) are removed, and agreeing design attributes are substituted, which maintain safety and desired operations. This philosophy is considered a speed management and behavioral design approach in which the objective is not necessarily to restrict speed, but to provide a roadway planned and designed where appropriate speed and operational safety is obtained and achieve a "self-explaining" look and feel for the certain type of highway facility. This is implemented by including in the design various roadway design features and treatments, including aesthetic enhancements, which are commonly associated with a "standardized" category of road, to communicate to the driver the sense of its type of function and the context of the facility. Particular attention is placed at the transition zones between differing road function/speed categories, to act as "gateways" that noticeably demonstrate and overtly accent the category-defining roadway design attributes. In this way, the new road function (and intended speed) is readily recognized and accepted by the driver. An example of a transition is between a relaxed and open, high-speed rural countryside and a busy, more confined, low-speed suburban community. Another example of a transition is between a high-speed and commercial, arterial highway and a low-speed and interpretive park road. The techniques for managing the variations in operating speed described in Section 4.4.4.9.3 may be applicable to these transitions. In addition to emphasizing the transition zones, the design and safety aspects appropriate for the differing road function/speed categories, such as described in Section 4.4.4.9.1 and Section 4.4.4.9.2, should be fully provided. For additional description of the concepts and philosophy of a self-explaining, self-enforcing road design, see *Geometric Design Practices for European Roads*, FHWA, June 2001.

4.4.5 FLEXIBILITY IN HIGHWAY DESIGN

The design standards shown in Exhibit 4.4-A provide considerable flexibility in the determination of specific design criteria applicable to particular highway types and conditions. Flexibility in the design standards is associated with the purpose and function of the highway and other design parameters (e.g., traffic volume and type of vehicles).

The determination of applicable highway standards is intended to cover broad classifications of highway facilities. However, each project is unique. The setting and character of the area, the values of the community, the needs of the highway users, and the challenges and opportunities of the site are unique factors that must be considered with determination of design criteria for each highway project. The applicable standards provide flexibility in the selection of highway design criteria, which requires decisions on the part of the project design team and stakeholders. The standards allow designs to be tailored to the particular situations encountered in each highway project. Often, the flexibility within the range of criteria provide enough flexibility to achieve a balanced design that meets both the objectives of the project and is sensitive to the surrounding environment and context.

The interdisciplinary project development team is expected to use their respective expertise and judgment to develop the conceptual and preliminary design of each road to fit into the natural and human environments, while functioning efficiently and operating safely. Each highway situation must be evaluated to determine the possibilities that are appropriate for that particular project, using an interdisciplinary approach to explore various concepts, options, constraints and flexibilities.

Refer to the FHWA Publication No. FHWA-PD-97-062, *Flexibility in Highway Design*, 1997 and *Achieving Flexibility in Highway Design*, AASHTO, 2003 for additional guidance in using flexibility in the selection of applicable design standards and criteria.

4.4.6 RISK ASSESSMENT

The safety and operational effects of various design standards and criteria must be recognized and assessed as part of the conceptual and preliminary design phase during the selection of the applicable design criteria and in their application. It is not feasible or intended for highway projects to be entirely risk-free, as there are potential rewards to the project when risk is taken. Knowledge of the traffic and safety conditions for each project, as well as the basis and assumptions underlying the design standards, is essential in order to understand the risks associated with various design decisions involving the selection and application of design standards. In many cases, the risks associated with conceptual and preliminary design decisions can be mitigated with inclusion or enhancement of other design or operational features, which may offset the risk.

The safety effects (risks) of providing geometric design features that are less than the standard for a particular design speed are not well established, although new methods for estimating the safety effects are available (e.g., the Interactive Highway Safety Design Model (IHSDM) and its library of references). The safety risks may be lowered by providing mitigating features (e.g., additional traffic control devices, enhanced warning signs with advisory speed plaques, delineation, markings) and by modifying the roadway and roadside (e.g., shoulder widening, enhanced recovery area, improved barrier) to reduce the severity of crashes. However, the degree to which the safety risks may be reduced by this type of mitigation is difficult to quantify.

On a project-by-project basis, a consistent level of risk should be maintained from programming through construction. Where risk levels vary with different design or construction options, these risks must be fully explained, especially where there are disagreements over cost, impacts, safety, service life, aesthetics, etc. Risk levels may vary between different disciplines or may impact other disciplines, or may cause risks to arise later in the project delivery process. Decisions resulting from risk-driven conflicts must be fully discussed and documented by the interdisciplinary project development team. The project manager will generally lead the decision-making process using a collaborative interdisciplinary approach to resolve disagreement over the acceptable level of risk. The FLH Branch Chiefs will normally oversee and endorse the level of risk taken to achieve a consistent office-wide level of risk acceptance over time. Where risks are elevated the endorsement of the project manager, Division Functional Discipline Manager, Branch Chiefs, Directors or Division Engineer may be necessary. Exhibit 4.4-D describes categories of risk level and the type of endorsement that is anticipated.

Risk Level	Endorsement	Guidance Format
Expected/Typical	Interdisciplinary Team (Cross-Functional Team) Representative	PDDM acknowledges risk tolerance and provides policy, FLH *Standard Practices*, and guidelines.
Elevated	Project Manager and Division Discipline Functional Managers	PDDM discusses technical considerations and mitigation
High	Branch Chiefs or Directors	Procedures for design exceptions
Very High	Division Engineer	Project-specific design standards and criteria

Exhibit 4.4-D RISK ASSESSMENT AND ENDORSEMENT LEVELS

Refer to Chapter 8 for guidance on assessment of the safety and operational risks associated with existing roadway conditions, and refer to Chapter 9 for guidance on assessment of the geometric design and operational effects, risks and mitigation for specific geometric design elements and features.

4.5 PRELIMINARY ENGINEERING INVESTIGATION

The following Sections provide guidelines for performing the:

- project scoping investigation and assessment,
- preparation of the project scoping report, and
- corridor studies and report (if applicable).

The basis for this preliminary engineering investigation is the problem definition and evaluation of existing information that is gathered as described in Section 4.3, together with consideration of the applicable design standards and controls as described in Section 4.4.

The result of this preliminary engineering investigation is an initial recommended course of action that will be carried forward for development during the preliminary design phase as described in Section 4.6, including any alternatives that will be developed as described in Section 4.7. The results of the preliminary design and alternatives analysis are established as described in Section 4.8.

4.5.1 PROJECT SCOPING INVESTIGATION AND ASSESSMENT

The project scoping investigation and assessment are performed in advance of preliminary design. The interdisciplinary field inspections and engineering investigations involved with identifying and quantifying a highway's deficiencies and needs, evaluating the feasibility and identifying a proposed course of action with improvement alternatives and conducting engineering analyses that result in a report identifying feasible proposed improvements are collectively called a project scoping study. Project planning study, route study, feasibility study, reconnaissance study and preliminary engineering study are all terms used by different agencies and offices to mean some form of project scoping activity that falls within the conceptual study phase. Within FLH, the project scoping report may also be known as a design scoping report, project identification report or reconnaissance report. For evaluation of road corridors on new alignment, a Corridor Study may also be needed (see Section 4.5.3).

The project scoping study initially documents the major needs, issues, constraints, scope and feasibility of proposed improvements from which the more comprehensive, interdisciplinary preliminary engineering activities, surveys, investigations, environmental studies and analysis can be effectively planned and budgeted.

A project scoping study should be performed as part of the pre-programming activity to help prioritize or screen projects being considered for inclusion in the multi-year program (refer to Chapter 2), and to help streamline the project development activities. The pre-programming scoping study may not be as detailed as described in this Chapter. If the project scoping study was not completed earlier, the remaining project scoping study activities are performed directly after the project is programmed for funding.

The project scoping study is performed using an interdisciplinary, interagency approach with close coordination of the land management agency and principal stakeholders of the facility. For reconstruction projects, the interdisciplinary team should thoroughly explore the existing corridor for opportunities to improve safety, traffic operations and efficiency including realignment and reconstruction of the existing roadway within the existing corridor.

For purposes of defining the series of investigations during the conceptual studies phase for Federal lands, the project scoping study is a combination of the field inspections and existing engineering data used to identify and quantify a highway's deficiencies and needs. The data are gathered and summarized in the Project Scoping Report. As part of this study, recommendations for further study will also be made in order to develop a course of action with suggestions for investigating improvement alternatives and conducting engineering analyses that ultimately result in a preferred alternative are collectively called a project scoping study.

4.5.2 PROJECT SCOPING REPORT

The results of the field inspections and compilation of existing engineering data used to identify and quantify a highway's deficiencies; user needs and context are gathered and summarized in the Project Scoping Report. Refer to Section 4.11 for specific information requirements, report format or checklists that are applicable. As applicable to the individual project scope of work, the final project scoping report should contain the information described in the following Sections.

4.5.2.1 Introduction

Describe the authority, purpose and need for the study. It should include the relevant project history, a general project description and describe the nature of the work. It should also describe the major issues, concerns and opportunities that will be addressed by the study.

4.5.2.2 Resources Used

Identify all sources of information, maps and available data obtained for the study. This is not merely a listing of the agencies that provided data, but a summary of all of the existing reports, as-constructed plans and previous studies reviewed as well as any site investigations performed.

4.5.2.3 Route Description/Termini

The study termini should be established to be comprehensive and logical, although the overall route may include portions that already conform to standards or meet the purpose and need. Identify any segments along the route where significant changes occur in traffic use, speed, roadway width, terrain or overall condition. If this project is one of several on a corridor, also provide a brief summary of the other projects, their limits and how they relate to this study.

4.5.2.4 Preliminary Programming and Funding Information

Based on preliminary program budgets or expectations of the land managers, a budget is established for the pending work. This Section should document those initial assumptions so the project team is aware of the anticipated scope of improvements and the funding constraints that may exist. This includes the funding type(s), program fiscal year(s), construction cost, engineering and other project delivery costs. This Section should also describe any inter-agency agreements that have been made that will help fund this project.

4.5.2.5 Project Contacts

A conceptual study is a discovery process. The time required to complete these discoveries can frequently result in new participants being assigned to the study from the various contributing agencies. To keep all of the agencies informed, and to provide contact information to those that are added to the team, the contact information of all participants should be included in the reconnaissance reports. In addition to their respective phone, mail and e-mail addresses, it should include their title and what discipline/area they were responsible for.

4.5.2.6 Summary of Purpose and Need

The purpose and need is initially developed in the planning and programming phase. The purpose and need statement should be refined by the interdisciplinary/interagency team in collaboration with the environmental process. Refer to Chapter 3 for additional information on this process.

This purpose and need description is more detailed than the general purpose and need described in the introduction. Some examples of points that could be addressed include:

- Describe the primary highway related needs for improvement of this route (e.g., safety, operational, capacity, structural deficiency, travel corridor demand, system continuity). Also, describe the secondary needs for improvement of this route (e.g., water quality).
- How would improvement of this route aid in the development, use, protection and administration of the land and its renewable resources by the land management agency?
- How would improvement of this route aid in the enhancement of economic development at the local, regional and national level?
- How would improvement of this route aid in the continuity of the transportation network serving its dependent communities and the land management agency?
- How would improvement of this route aid in the mobility of the transportation network and the goods and services provided?
- How would improvement of this route aid in the protection and enhancement of the surrounding environment associated with the land managing agency and its renewable and nonrenewable resources?
- Have there been public requests for improvement of the route?

The purpose and need for improvement of the facility should be related as closely as possible to the intent, authority and eligibility of the enabling program that is funding the project.

The purpose and need should include a summary of the available traffic data and crash data.

4.5.2.6.1 Summary of Traffic Data

Based on the evaluation of existing traffic data and other related information that is collected, summarize the average daily traffic and the projected traffic level for the future design period.

4.5.2.6.2 Summary of Crash Data

Based on evaluation of the current traffic crash statistics for the route, summarize the crash information. Categorize data according to route segments and spot high-frequency locations. This must be supplemented with field identification of potential crash sites that may not be discernible from the past data.

4.5.2.7 Climate, Physiography and Geology

Provide a general description of the climate, significant geographic features, land uses and geology of the area.

4.5.2.8 Controlling Factors

Describe all controlling features involved in reconnaissance of the route. The following provides some examples:

- major intersecting roads;
- railroad crossings;
- bridges and other structures;
- high-voltage power line crossings (i.e., record elevation of low point in cable and air temperature);
- major utilities and/or special services (e.g., gas and oil pipelines, water distribution lines, telecommunications trunk lines);
- roadside developments (e.g., private commercial and residential development, visitor centers, lodgings);
- historic structures and features, special architectural, decorative or aesthetic features and aspects;
- floodplains, wetlands, major natural features, major rock outcrops, etc.;

- existing, unique features outside the limits of the pavement that define the context of the roadway corridor that should be preserved or avoided (e.g., take photos of any vistas or vegetation to preserve, unique outcroppings);
- especially difficult terrain; and
- restrictions on, or difficult construction access, staging, etc.

4.5.2.9 Criteria to Be Applied

This section should provide the primary design standards and criteria to be followed for the development of the various alternatives for all disciplines. Describe the source and range of proposed preliminary roadway design standards, especially alignment and grades, roadway cross sections, type and cost of structures and other preliminary design elements being considered. Describe all the proposed controlling geometric design criteria and any proposed design exceptions as outlined in Chapter 9, Section 9.1.3.

4.5.2.10 Preliminary Recommendations for Study

During the project scoping efforts, the project study team will have insights as to what is anticipated to address the purpose and need. These recommendations will form the scope of work for the preliminary engineering stage. All of the alternatives to be considered and the breadth of effort needed to investigate these alternatives should be described to properly convey the vision of the reconnaissance team to those performing the preliminary engineering efforts.

4.5.2.11 Environmental Features and Concerns

Briefly describe the overall level of environmental sensitivity of the facility and the action, and the anticipated type of NEPA document, that is recommended by the environmental discipline staff. Describe the proposed lead agency and cooperating agencies for the NEPA document. Briefly describe the anticipated level of applicability of the following key issues, which are addressed as part of the environmental process:

- wildlife resources (e.g., T&E species, State-listed species, species of local concern);
- aquatic resources (e.g., wild/scenic rivers, fish passage, spawning restrictions, NOAA fisheries);
- historic, cultural or archeological resources (e.g., National Register eligible sites, SHPO – Section 106 involvement);
- tribal or traditional cultural properties;
- Section 4(f) requirements;
- wetlands or water quality resources;

- Scenic Byway or aesthetic resources;
- public concern or controversy; and/or
- other key environmental issues.

4.5.2.12 Summary of Functional Discipline Considerations

This section will provide direction for each engineering functional discipline to complete during the development of the preliminary engineering (30 percent plans). For each discipline, provide the scope of services to be investigated during the preliminary engineering stage.

4.5.2.12.1 Roadway Design

Describe the overall existing horizontal and vertical alignment characteristics, cross section elements, intersections, public access approach roads and other major geometric features. Describe the existing and proposed traffic operations and user characteristics. Provide a listing of roadside features that will control or have a major influence on the design. Describe major roadway features (e.g., parking areas, walls, curbs, barriers, sidewalks, fencing) that may be left in place or rehabilitated. Describe the general roadside conditions, slopes, drainage, vegetation, aesthetic features and other factors that will heavily influence the design criteria and development of the preliminary design that are not addressed in Section 4.5.2.8. Describe the overall level of roadway improvements that are proposed, and level of design development that is anticipated during the preliminary design phase.

Based on the evaluation of the existing geometry, describe any horizontal and vertical alignment problems that must be specifically addressed or studied further. If there are alternatives to be considered, describe potential realignment options that should be considered, provide the general scope and the reasons for the investigation. Describe the major maintenance issues that the road owner is dealing with that should be addressed in the roadway design.

Perform a design assessment of driver information needs and describe locations with potential for either insufficient positive guidance information, or information overload, including sight distance needs for these conditions. Refer to the *Green Book*, Chapter 2 § Driver Performance ~ Design Assessment, for guidance on these considerations.

Identify any intersection problems that must be improved or problems with approaching roadways that tie into the roadway that must be studied further. Associated with this, identify any private driveways or access points that require special improvement or investigation within the project limits.

Describe other roadway features to be rehabilitated or rebuilt (i.e., parking areas, pullouts, picnic areas, entrance gates, concession areas, rest areas, bus shelters). Identify who will provide the design plans if they are not part of this study.

In addition to the roadway, identify any other facilities that must be realigned (e.g., bicycle, pedestrian, equestrian, snowmobile).

4.5.2.12.2 Traffic/Safety Investigations

Traffic and crash data are described in Section 4.5.2.6. Investigate the crash history data and describe any identifiable problems with sight distance, clear zone, roadside hazards (e.g., trees, headwalls, utility poles, boxes), pedestrian crossings, unusual traffic conditions or poor operations. Identify constraints for obtaining clear zone and forgiving, recoverable roadside conditions at completion of the construction. Describe locations where needed improvement of the roadside is difficult, and where barriers may be warranted. Describe any identifiable deficiencies in the roadside safety hardware (e.g., sign supports, barriers and terminals, bridge rails and terminals) for compliance with current standards for crashworthiness. Describe the condition of traffic control devices (e.g., signs, markings, delineation, retroreflectivity, messages) and the scope of needed improvements. Describe the overall level of safety and traffic operations improvements that are proposed.

In order to develop and evaluate the recommended alternatives, identify any site-specific traffic counts that are required to help determine the future traffic needs of the facility. These could include general counts, turning movements at busy intersections or projected growth information due to proposed developments in the area.

4.5.2.12.3 Survey and Mapping

Describe the level of existing survey, mapping or GIS information that is available. Describe the type(s) of survey that is recommended or that should be considered. Describe the factors affecting the survey work (e.g., as availability of control, monuments, sky exposure for GPS, photogrammetric mapping or LiDAR data collection, terrain and ground cover, traffic). Describe the extent of special features that will require precise location (e.g., walls, fences, utilities, bridges).

The type and scale of surveys and mapping required are dictated by the terrain and land use intensity of the route corridor area and the level of preliminary design analysis to be conducted. The maps must be complete, current and provide full details of topography and physical features.

Mosaic reproductions or photographic prints may be used in conjunction with USGS quadrangle maps or satellite imagery to show overall existing routes. Development of new photogrammetric mapping or other imagery for scoping studies may be used where feasible and cost-effective.

Topographic mapping for areas of moderate to intensive land use should preferably be to a scale of 1:1000 (1:1200) or 1:2000 (1:2400) with a 1-m (5-ft) or 2-m (10-ft) contour interval. In areas of limited or homogeneous land use and in mountainous or heavily forested areas, a map scale of 1:5000 (1:4800) with a 3-m (10-ft) or 5-m (20-ft), contour interval will suffice. If only broad reconnaissance is to be done, existing USGS quadrangle maps with 1:24,000 scale and 5 m (10 ft) or 10 m (40 ft) contour intervals may be adequate.

Further survey and mapping discussions are contained in Chapter 5.

4.5.2.12.4 Right-of-Way

Describe existing right-of-way in terms of existing widths, types of ownership and types of property improvements adjacent the roadway. Describe the overall extent of the route that is private and public property and the approximate number of landowners that may be affected. Identify the agency and contacts that have responsibility to coordinate and pay for any additional right-of-way. Describe the level of existing right-of-way documents that are available. If right-of-way plans need to be prepared for acquisition, describe the agency responsible for preparing documents and any unusual requirements for preparation. For public land, describe any special use permits for the roadway or related uses. Describe the approximate area of private and public right-of-way that may be affected or acquired for purposes of estimating the level of right-of-way activities. Describe any special fencing requirements or access management features that are anticipated.

4.5.2.12.5 Utilities

Describe the type and location of existing utilities. Identify if any known utilities will likely need to be relocated or avoided. Describe any special considerations regarding utilities that are unusually sensitive or difficult to address for clearance prior to construction. Identify the agency responsible for utility issue coordination and costs for relocation. Develop a contact list of utility representatives. Describe any existing utility agreements or easements between the roadway owner and the utilities. Describe entities (e.g., water and irrigation districts, transmission lines, railroad facilities).

Most existing utilities can be easily identified in the field or summarized by utility section maps. If there are specific utility issues that must be addressed during the evaluation of alternatives, describe what these issues are (outage limitations, lead time for acquiring materials, impacts to buried facilities due to changes in grade), and what level of investigation is necessary to complete the alternatives analysis. For most studies, only coordination with the utility owners will be required to determine their specific relocation needs and schedules. If there are relocations required where either hazardous or environmental consequences could occur, these should be fully investigated as part of the alternatives analysis.

4.5.2.12.6 Permits

Describe the likely permit actions that will be needed (e.g., Section 404, NPDES, FS or NPS special use permits for material sources or plants, staging, borrow or waste). Describe any State permits anticipated (e.g., air quality, water quality, highway access or encroachments).

Are there any known permits that will be required as part of the evaluation of alternatives. If special surveys are required (e.g., geotechnical, ground surveys), will special use permits be required before this work can begin? Special permits for the purpose of study investigations could include:

- USACE 404 permits, if access or disturbance into waters of the US are required;
- NPDES permits, if the geotechnical investigation will require pioneer roads or major disturbances to the land;

- access permits from private property owners or Tribes; and
- cultural clearances for any ground disturbing activities.

4.5.2.12.7 Geotechnical

Geotechnical specialists should perform a reconnaissance early in the conceptual studies phase. This will assist in determining the cause for instability or pavement problems on the existing highway and provide information on potential problems for constructing the alternatives under consideration. This will also assist in identifying potential sources of higher-quality materials within the area, and opportunities for optimizing the subgrade, base and pavement design. Normally, a visual inspection of the study area is performed. Hand samples may be collected and tested to categorize the materials and support the visual inspection. More extensive investigations may be required if existing information is inadequate and/or incomplete.

Typically, a geotechnical reconnaissance report addresses the following:

- geology of the study area;
- existing and/or potential unstable soil conditions;
- major geological features that will constrain the design and not described above in Section 4.5.2.8; and
- location of possible sources or sites for base, surfacing and topsoil materials.

Identify the geology of the general area. Use a geologic map if one is available. Interpret and show the relationship of the geology to the proposed route. Include the location and the extent of the following features:

- landslide areas;
- solid rock;
- unconsolidated material;
- ground water and surface water conditions;
- availability of road construction materials within the project (e.g., type of deposits, quantity and quality); and
- recommendations for type of materials to be used (e.g., borrow, waste sites, contractor staging areas).

More in-depth investigations are conducted later in the preliminary design process as described in Chapter 6, Section 6.3.

4.5.2.12.8 Pavements

Describe existing pavement and surfacing conditions and the type of surfacing options that should be considered during preliminary design. Describe the type and areas of existing pavement distress and document with photographs. Describe the apparent cause of any major distress areas (e.g., subgrade failures, poor drainage, severe oxidation). Describe any major factors that will influence the pavement design (e.g., heavy truck traffic, buses) and any special areas of concern (e.g., heavy truck or bus parking or stops, pedestrian or equestrian traffic). Describe the anticipated type of pavement and base construction that should be investigated (e.g., pulverization, recycling, subgrade stabilization, overlay).

4.5.2.12.9 Hydrology and Hydraulics

Describe the location of all major drainage crossings and document with photographs. Describe the overall condition, sizing, materials and performance that are evident in the existing drainage facilities. Describe any significant scour, erosion, sedimentation, debris, abrasion and other problems, and if bridge waterway issues have been documented in reports. Describe any channel modifications that are anticipated and any floodplain issues that will need to be investigated. Describe the overall level of hydrology and hydraulics improvements that are needed and proposed. Describe any overriding local or State requirements for hydrology methodology or hydraulic design.

Generally, the detailed evaluation of the drainage basin and the specific waterways will be completed during the 30 percent design development, as described in Chapter 7. If the size of a new or improved drainage structure could have an impact on the outcome of the alternatives analysis, the hydrology investigation should begin during the preliminary engineering phase.

4.5.2.12.10 Structures

Describe the existing structures (e.g., bridges, large box culverts, retaining walls, tunnels) including the type, span lengths, dimensions, apparent condition, railing and any utilities. Describe the waterway opening or roadway clearances, any visible scour, sediment deposition or any apparent instability around the structure. Describe the available data (e.g., as-built plans, inspection reports, structure ratings, foundation and hydraulic information). Document the existing structures, any apparent deficiencies and upstream and downstream stream channels with photographs. For proposed new structures or improvements to the existing facilities, describe the preliminary options that should be considered for structure type, layout and alignment. Describe the proposed structure's basic requirements including flow capacity, number of lanes, shoulders, sidewalk, utility, vehicle loadings and aesthetic considerations.

The detailed evaluation of structures and the selection of the desired type, size and location of a bridge or structure are typically completed after the roadway alternatives are complete. The detailed scope of these investigations is described in Chapter 10.

During the project scoping study, investigate and provide all available structure site data. Document typical roadway section, approach rail, potential environmental issues and apparent right-of-way limits at each structure crossing. When available, obtain roadway plan and profile sheets, mapping and right-of-way limits that could have impacts on both the construction and maintenance of the bridge. For especially large structures, also include a discussion on how materials can be delivered and erected on the site as these requirements may be constrained environmentally.

In many cases, structures provide the only source of wildlife connectivity from one side of the highway to the other. Work with the wildlife agencies to be certain clearance, openness and capacity issues for wildlife are clearly understood and agreed upon by the project team.

4.5.2.12.11 Constructability, Construction Sequencing and Construction Materials

Describe all sources of construction materials available in the area. Identify pit sites by location and pit name or number, if known, and the location of local construction materials' suppliers. Describe any known restrictions for construction operations, equipment operation, hauling, staging, water or storage that are not described above in Section 4.5.2.8. Describe any construction staging or traffic control or traffic management requirements that may influence the type or scope of work that is proposed, sequencing of the construction work or affect construction costs. Describe any unusual housing or transportation issues for construction workers or suppliers. Describe any difficult construction problems or issues encountered on previous projects.

4.5.2.13 Cost Estimate

Prepare a cost estimate of the anticipated preliminary engineering, construction engineering, right-of-way appraisal and acquisition, utility adjustments and per-mile construction costs (Class C estimate). Refer to Section 4.8.15.

4.5.2.14 Exhibits

Use exhibits to include route maps or aerial mosaics depicting the location of the existing contextual features, proposed improvements, typical roadway sections, vicinity maps, route profiles, physical characteristics outlined on reconnaissance study form and detailed cost estimates of the alternatives.

4.5.2.15 Site Photographs

Ground photographs and/or oblique aerial photographs should be taken of controlling elements in the field. These can be used in analysis, report illustration and for exhibits in the public involvement process.

4.5.3 CORRIDOR STUDY

When formulating improvement alternatives, it occasionally becomes apparent that a highway should be considered on new alignment in a corridor outside of the existing road. In fact, there may not even be a road connecting the termini, although this situation is not common. For most projects, the improvements are confined to the existing corridor and frequently are confined to the existing disturbed area within the corridor, such that a corridor study outside of the existing road is not applicable.

When applicable, new highway corridors are usually identified and evaluated separately from an alternative's preliminary design standards although they must be compatible with all the components that make up the alternatives. A highway corridor can be defined as a linear strip of ground that connects termini and has sufficient width and variable positioning on the terrain to allow a road with its preliminary design standards to be built within its borders.

Depending on length and terrain, most corridors are between 30 m (100 ft) to 120 m (400 ft) wide. Its position on the topography is tied to existing land forms and sometimes defined in relation to a survey traverse line (see Chapter 5).

Highway corridors are normally established with three general objectives in mind:

1. **Size**. The corridor must be broad enough to allow the highway centerline to be positioned or shifted in conformance to the geometric standards and to achieve reasonable cost effectiveness.

2. **Features**. The geographical and geophysical features should be stable and compatible with the construction, operational and maintenance requirements of the highway.

3. **Environmental Impacts**. The environmental impacts should be minimized and aesthetics maximized.

Historically, the process of investigating new highways and corridors was called a location survey or reconnaissance study. Currently, much of the process is covered by the environmental analysis and documentation. However, the basic procedures in establishing feasible highway corridors are still valid.

A thorough initial investigation is essential in making effective corridor determinations. If the most feasible, serviceable and economical corridor is not determined at this stage, no amount of engineering effort can overcome the inherent deficiencies that will exist. When presenting corridor evaluations, it is imperative that the same basic data and methods of investigation be used for each corridor studied.

Most corridor reconnaissance work is done using photogrammetric or other topographic maps supplemented with field data. On occasion, ground reconnaissance surveys are made as a substitute for or supplement to the topographic mapping.

Before beginning the study, review all available maps and photographs to determine if any additional data and mapping are needed for conducting the study.

The following information is pertinent to corridor studies:

- land use, population and density;
- geophysical and geological formations;

- potential of the area for future industrial, residential, farm or recreational development (i.e., land use changes);
- frequency, condition and type of existing roads and highways serving the area;
- existing utilities and facilities, planned and potential (e.g., transportation (other than highways) dams, power lines, gas and water lines, recreational areas); and
- photographs of controlling features.

4.5.3.1 Major Considerations and Physical Controls

The termini are the major controls of the route. From a strict user's standpoint, the most economical route is a straight line between the termini, both horizontal and vertical.

However, the practical economic location and the environmentally acceptable locations are based on a compromise between construction cost, user's cost and environmental impacts.

Physical controls (e.g., bridge sites, rock areas, valley and mountain sides, built-up areas, lakes and drainages) affect the construction costs.

4.5.3.2 Corridor Selection for Evaluation

Specific procedures should be followed in the selection of route corridors for comparative evaluation. Common points of termini for all routes to be studied should be identified in addition to any constraints that may limit alignment, grade and route location.

Typical constraints include the following:

- Limitations imposed by design standards (e.g., maximum allowable grades and curvature).
- Physiographic controls (e.g., landform and watercourse gradients, shorelines, property or jurisdictional boundaries, preemption of lands for other use) and the avoidance of known problem areas (e.g., unstable, highly erosive land forms).
- Economic controls, including encroachment on high cost lands or improvements, and alternatives involving features of excessively high construction cost.
- Mandated points of contact (e.g., intersection with a limited access facility where the access point is predetermined, access to a major point of interest that has a fixed location).
- Environmental controls, some of which are mandated by law, govern the avoidance of wetlands, prime and unique farm lands, habitat for endangered species, historical and archaeological sites and park lands.

4.5.3.3 Aesthetic Elements

Weigh the aesthetic qualities of the corridors under investigation as carefully as those that contribute to traffic safety, highway efficiency and structural adequacy. Gentle curves, easy grades and lanes with adequate clearance between passing vehicles contribute both to pleasant and safe driving. Both horizontal and vertical alignments should be coordinated to create a total roadway alignment that complements rather than disrupts the natural landform.

Pleasing appearance can usually be achieved at little extra cost if the road is located with these aesthetic elements in mind from the start. Further, roadside development (e.g., scenic vista, streamside parking areas), erosion control, flattening and rounding slopes, seeding and revegetation contribute significantly to roadway beauty and safety as well as reduce maintenance cost.

When the merits of competing locations are nearly equal, scenic quality may be a deciding factor.

4.5.3.4 Map and Photograph Study

Study the various alternative corridors between the termini using a large scale (e.g., 1:5000) map that shows the major topographic features (e.g., rivers, mountains, roads, cities, towns). Select the more representative and feasible alternatives to be evaluated in detail.

Study and analyze the collected material before gathering field information. If good photographic and map coverage is available, much of the corridor analysis can be done by stereo aerial photo analysis and map study. Impractical locations can logically be eliminated to concentrate on the more promising alternatives during the field investigation. Further refinement or screening of corridor location alternatives may occur during the field investigation.

4.5.3.4.1 Map Study

Study the topography between assigned termini to identify avenues through the terrain that may be a feasible road location and also difficult terrain that may be avoided. Ridges or watersheds are often feasible avenues, especially where there are long regular ridges leading in the desired direction. Valleys are also practical avenues if they lead in the desired direction. The most difficult corridor locations are those that cut across the natural avenues or those that lie in confusing terrain where the ridges and streams have no continuous well-defined direction.

Each possible avenue should be examined, and some may be quickly discarded as impracticable. Each practical route should be represented on the map using different colors or line symbols. Where the gradient might be controlling, the contour gradient intervals should be stepped out on the map with a divider or equivalent CADD technique to ensure that the route grade is within acceptable limits. Points where curvature may be critical should also be verified.

4.5.3.4.2 Stereo Aerial Photo Analysis

If available, examine stereo aerial photos. It is possible to check gradients on the photography using a stereoscope and an engineer's scale. Possible lines may be represented on the photos and compared with map locations. Stereo photo examination will yield information that may not be shown on a map, so if both the map and photos are available, both should be used.

A thorough map or stereo aerial photo study should investigate all possible routes within a band that is 40 to 60 percent as wide as the distance between termini. If adequate photo and map coverage are not available, consider viewing the terrain from a plane or helicopter before traversing it in the field. Under some conditions it is desirable to have uncontrolled aerial stereo and oblique photos of the route taken for use in the corridor reconnaissance.

The effort required for the corridor reconnaissance field investigation will depend on the effectiveness of the preliminary office studies, the accessibility of the route, weather, etc., and might vary from a day to weeks. The field investigation can be made by any means available (e.g., vehicle, horseback, by-foot). During this investigation, observe and note the forest cover, drainage, potential bridge sites or major drainage crossings, the nature and classification of the soil, rock outcrops, land use and anything else that might affect the alignment location.

Oblique and terrestrial photography can be helpful in studying and depicting proposed improvement corridors, and can be enhanced by visualization techniques to illustrate future highway improvements. These visualization techniques may be roughly prepared by photo-composition, or may require a preliminary design (i.e., alignment, cross section), to accurately depict the proposed improvements.

4.5.3.5 Corridor Study Report Format

When applicable, comprehensive corridor analyses of new alignment and corridor locations are sometimes documented in a Corridor Study Report. More frequently, though, this information is kept informal. In either case, corridor analyses are summarized in the major environmental documents (i.e., Environmental Assessment, Environmental Impact Statements). The corridor study reports not only contain the results of the corridor analyses but also summarize the preliminary design standards under consideration. In addition to the engineering information, the social, environmental and economic features of the alternatives (separate corridors) used in the analyses are presented at least in a general fashion.

The corridor study report should contain the following items:

1. **Introduction**. Describe the authority and purpose of the study.

2. **Resources Used**. Identify all sources of information, maps and data obtained for the study.

3. **Climate, Physiography and Geology**. Provide a description of the climate, significant geographic features, land uses and geology of the area.

4. **Preliminary Design Standards**. This section should include all traffic data and design criteria for the study. Describe range of proposed preliminary roadway design

standards, especially alignment and grades, roadway sections, type and cost of structures and other preliminary design elements being considered. Many of these are illustrated in a roadway cross section.

5. **Corridor Descriptions**. Provide a detailed description of each corridor studied.

6. **Comparative Evaluation**. This section should contain a comparative evaluation of routes studied. Include a dissertation of the related social, economic and environmental (SEE) impacts (e.g., changes in land uses, displacement of residences, disruption of communities, environmental mitigation measures, construction costs, road user costs, secondary economic factors).

7. **Benefit Cost Analysis**. An optional section that may be used to provide a benefit cost analysis for each corridor and the basis for them.

8. **Exhibits**. Use exhibits to include route maps or aerial mosaics depicting the location of the corridors, typical roadway sections, vicinity maps, route profiles, physical characteristics outlined on reconnaissance study form and detailed cost estimates of the alternatives.

4.6 PROJECT DEVELOPMENT AND EVALUATION FRAMEWORK

The project development and evaluation framework consists of the development of the design concepts and technical analysis for a recommended course of action as described in this Section, leading to the evaluation of any alternatives that may also be developed as described in Section 4.7. The development of the conceptual studies and preliminary design, and concurrent technical analysis, combines preliminary investigations by many of the engineering disciplines (e.g., traffic engineering, survey/mapping, geotechnical, hydraulics, structural engineering, roadway design) into a coordinated comprehensive design package, with assessment of a highway's transportation problems and an array of proposed context sensitive solutions. The analyses involve evaluating diverse field data, yet the analyses are preliminary or general in nature. A higher degree of technical detail is necessary in the final design phase.

The types and sequence of steps in the conceptual study and preliminary design process are described in the following subsections. The technical analyses are not always presented in depth, but references are given to the other Chapters where the preliminary and detail design requirements are discussed.

4.6.1 INTERAGENCY SCOPING AND PUBLIC INVOLVEMENT

Public involvement is part of the formal environmental process requirement. It provides necessary input and benefit during conceptual studies. As outlined in Chapter 3, Section 3.4, it is important to publicly announce the beginning of the conceptual studies and preliminary design phase, especially for the larger scale projects. This can help in identifying the local perspective on the major highway problems and driving difficulties along the route. Once alternatives have been developed, public input can be obtained through the environmental review process for the proposed improvement alternatives and their respective scopes of work.

More importantly, the interagency scoping and public involvement provides essential information about the natural, cultural and historic context of the environment encompassing the project, and the values of the community, and about the transportation facility users for inclusion in the development of preliminary design solutions. The interagency scoping and public involvement provides a mechanism for those affected by the project, as well as those representing the users of the facility, to add value and local expertise and to influence from the earliest possible opportunity the outcome of the transportation decisions and solutions that will affect them.

Additional information on project scoping and effective public involvement is provided in Chapter 2 of *A Guide for Achieving Flexibility in Highway Design*, AASHTO, May 2004.

4.6.2 DEVELOPING A PROPOSED COURSE OF ACTION

Depending on the degree of investigation and analysis in the planning and programming phase, a project's proposed course of action, as it enters the conceptual study stage, could vary greatly from a simple description of study area limits with intent to improve whatever is most needed, to a specific course of action (e.g., resurface the pavement, replacement of a particular bridge). To fully develop a complete, specific course of action, the overall highway deficiencies, transportation needs and context of the project vicinity must be well identified, quantified and evaluated in the conceptual studies phase. The initial recommended course of action developed during the preliminary engineering investigation as described in Section 4.5 should provide effective planning and launch for the more intensive activities performed during development and analysis of the preliminary design.

As the project develops during the preliminary design phase, the technical interdisciplinary investigations and analyses should provide the necessary data and technical recommendations to support development of the roadway alignments, grades, template cross sections, roadside design, structures type, size and location, anticipated construction activities, safety, traffic operations, technical performance (e.g., hydraulic, pavement, geotechnical), anticipated service life, sustainability, costs, user benefits and other aspects of the project; and that fully represent the effects, consequences and impacts of the proposed action.

For small projects, RRR improvements, and projects with limited or well-defined effects and impacts, the preliminary design and proposed course of action are readily developed with limited investigations and fewer technical disciplines that require involvement. For these type projects many of the following activities are not applicable, or should be reduced appropriately.

4.6.2.1 Definition of Project Objectives

To establish a proposed course of action, the designer must recognize the existing facility, its deficiencies and future needs, the user needs, the context of the facility and then describe the type of improvement that meets objectives. The objectives are typically to provide a facility for the highway user that fulfills the following:

- fulfills the purpose and need for proposed action,
- fulfills the operational and safety needs of the users,
- meets the convenience and safety standards for that system of highways,
- is cost-effective to build,
- is compatible with the context of the facility,
- avoids or minimizes environmental impacts, and
- minimizes maintenance costs.

A typical course of action addresses the road's width, alignment, surfacing, major structures, roadside features and the general types of construction items needed to implement these improvements.

The intent is to describe the type of proposed improvements, but allow flexibility so various alternatives can be considered that will accomplish the proposed course of action.

4.6.2.2 Safety and Operational Needs

A comprehensive preliminary design will evaluate and include the type of solutions that will address the safety and operational needs of all users, as well as non-users affected by the facility. Refer to Chapter 8 for more detail on what is required.

In addition, the preliminary design should address winter driving conditions including problems of removing snow and ice as addressed in Section 8.5.7. Rural farming areas may also present unique problems of moving farm machinery on the highway.

4.6.2.3 Traffic and Land Use Projections

Evaluation of data on traffic and projected roadway use requires a thorough research effort. Primary source agencies are Federal, State and local road administration and planning agencies. In some instances, it may be necessary to conduct special traffic studies as a part of the conceptual study.

Evaluate current and future traffic projections on the following subjects:

- traffic data on existing facilities:
  + average daily traffic,
  + seasonal average daily traffic,
  + peak hourly volumes, and
  + design hourly volumes;
- traffic trends, past and projected;
- classification of vehicles (e.g., percent passenger vehicles, percent trucks and buses and percent recreation vehicles);
- directional split;
- turning movements at major intersections;
- speed and delay data; and
- conflict study data.

Refer to Chapter 8 for more details on how to develop this information. Speed and delay data and conflict study data are optional depending on specific project requirements.

4.6.2.4 Context and Environmental Objectives

During the conceptual and preliminary design phase, designers cannot work at solving the transportation problems of a project in a vacuum. It is important that during the development of concepts that input from all of the various disciplines, agencies, stakeholders and the public, working together, can have the greatest positive impact on the design features of the project. In fact, the flexibility available for highway design during the detailed final design phase is limited a great deal by the decisions made at the earlier stages of planning, programming, conceptual studies and preliminary design. Therefore, it is important to plan ahead during the conceptual studies phase and to fully consider the potential effect that a proposed facility or improvement may have while the project is still in the preliminary design phase. During concept development, key decisions are made that will affect and limit the design options in subsequent phases. Some questions to ask at this stage include:

- How will the proposed transportation improvement fit within the general physical and social character of the area surrounding the project?
- Does the design need to have unique historic or scenic characteristics?
- How does the design reflect the safety, capacity and livability concerns of the community?

Answers for these types of questions should be found during the concept development phase, as well as in public involvement during concept planning. It is important that all of the issues, concerns and opportunities identified for maintaining the character and scenic integrity of the highway are clearly defined at the onset of the concept stage, so they can be either accommodated or mitigated. Factors to consider during the planning stage of project development are presented in Exhibit 4.6-A.

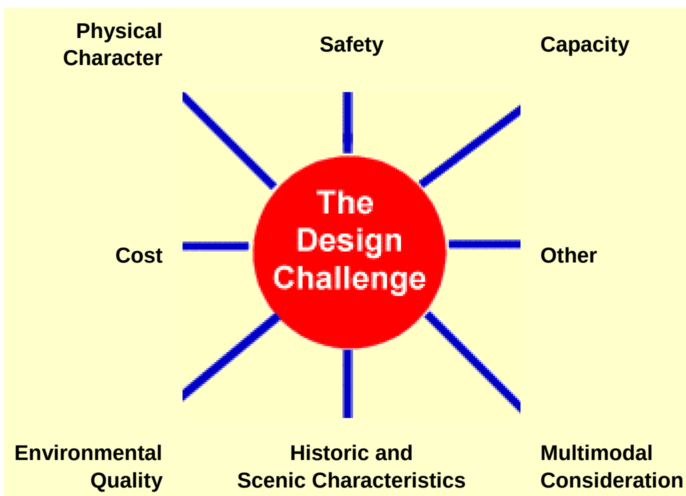


Exhibit 4.6-A FACTORS TO CONSIDER IN PLANNING

Additional insights and information for developing concepts that fit within the context of the projects surroundings can be found in the FHWA document, *Flexibility in Highway Design*.

4.6.2.5 Reconstruction Versus RRR Improvements Evaluation

As part of the project development framework and determining the scope of work, it must be clearly stated why the study effort should pursue a resurfacing, restoration and rehabilitation (RRR) approach versus a reconstruction approach to completing the improvements. This discussion should provide the justification for either reconstructing the current roadway, or providing the proposed level of effort to improve the current roadway. This justification should focus on the operational benefits and user benefits for proceeding with either approach. If a RRR approach is selected, both the benefits and consequences of deferring full reconstruction improvements must also be described. These include safety risks and the operational and life cycle construction and maintenance costs.

4.6.3 DEVELOPMENT OF THE PROJECT AGREEMENT

The purpose of the project agreement is to establish and reach agreement with the primary stakeholders the overall scope, schedule, budget, roles, responsibilities and quality expectations for delivery of the proposed project. The project agreement should address the following items:

- description and overall scope of the project;
- purpose for the project;
- general approach to project delivery;
- quality expectations;
- schedule of milestone activities and responsibilities;
- functional activities and responsible party (e.g., environmental compliance, design and technical services, construction, maintenance);
- funding sources, amounts, and proposed budgets of functional activities; and
- roles and signatures of primary stakeholders.

Refer to Section 4.11 for guidance on the format for specific project agreements as applicable for each FLH Division.

The project agreement should be in place before significant preliminary engineering work is begun or significant costs are incurred. The project agreement is typically prepared with input and involvement of the interdisciplinary team and program agency stakeholders.

4.7 ALTERNATIVES DEVELOPMENT AND EVALUATION

While the categories of alternatives indicate the proposed action, more specific terms must be used to describe an alternative beyond the general physical characteristics to evaluate its operational, safety and structural performance. The roadway width, design speed and surface type are the main elements of the general design criteria used to describe an alternative's preliminary design standards. Other elements (e.g., typical roadway cross section, preliminary line and grade, grading/clearing limits, auxiliary lanes/tapers, right-of-way widths) are sometimes included when the environmental analysis considers more detailed information to evaluate roadside impacts.

The intent of conceptual studies and preliminary design is not to develop the final design of the project, but to provide direction and scale of the improvement. Given this direction, a practical, cost-effective design of each of the proposed alternatives should be developed for relative comparison.

The alternatives evaluation should do the following:

- identify, evaluate and compare benefits and impacts of each alternative;
- establish design flexibility;
- define commitments to protect and preserve the environment for each alternative; and
- provide project implementation guidance.

Preliminary design studies define the project by line and grade, right-of-way limits, construction quantities and roadway geometrics in general terms based on projected traffic volumes, terrain and other special features. During the final design phase of the project, these activities will be addressed in more specific detail (see Chapter 9).

Once the proposed purpose and need and project objectives are established, all reasonable alternatives that can accomplish the objectives are identified. These should be practical engineering solutions to the identified problems (e.g., current deficiencies, future needs) within the overall limits and intent of the planning and programming goals.

Initially, alternatives might cover quite a range or scale of improvements, but they should be condensed to three or four succinct alternatives for which further engineering analyses can be applied. Otherwise, the details, data and description become very cumbersome to handle. The basic categories of alternatives to be considered on most road upgrading are described in the following Sections.

4.7.1 TYPES OF ALTERNATIVES

4.7.1.1 No Action

The no-action alternative would only continue the routine maintenance of the facility and does not include any upgrading that would change the road's operation or extend its service life.

4.7.1.2 Transportation System Management (TSM)

This alternative should always be considered when upgrading a road. It consists of travel controls and/or limited construction to maximize the operation and efficiency of the existing facility without major reconstruction or new construction. Sometimes these controls might include one of the following:

- accommodating the existing traffic on other routes or with different types of vehicles;
- posting vehicle restrictions and load limits; and
- providing an alternate, more attractive mode of transportation.

This form of TSM alternative is only marginally effective for Federal Lands Highway Programs because of the outdated, rural highway systems and automobile dependency present in most FLHP situations.

4.7.1.3 Resurfacing, Restoration and Rehabilitation (RRR)

Resurfacing, restoration and rehabilitation (RRR) projects are TSM alternatives with limited construction efforts that can be very cost-effective. The objective is preservation and extension of the service life of the existing highway and enhancement of safety without substantial costs, construction impacts or major right-of-way acquisitions. Generally, RRR projects do not reconstruct the highway for the purpose of achieving full geometric standards. However, a safety-conscious approach should be used to develop RRR projects. Refer to FHWA Technical Advisory T 5040.28, *Developing Geometric Design Criteria and Processes for Non-Freeway RRR Projects*, and dated October 17, 1988 for guidance in the development of RRR projects.

RRR work is undertaken to preserve and extend the service life of an existing highway and enhance highway safety. This may include placement of additional base and surface material and/or other work necessary to return an existing roadway to a condition of structural or functional adequacy. The RRR work is generally done on existing alignment. This retains or salvages a substantial amount of the existing surfacing, but may include some upgrading of geometric features (e.g., minor roadway widening, flattening curves, improving sight distances).

RRR projects are customized for individual situations and often result in exceptions to current design standards. Substandard geometric design elements require approval as design exceptions (see Chapter 9). As stated in the *Green Book*, existing roads that do not meet the guidelines for geometric design are not necessarily unsafe and do not necessarily have to be upgraded to meet the design criteria; however, all substandard elements must be identified and evaluated. The improvements, whether only at spot locations or continuous, should acceptably meet existing and preferably future (i.e., 10 to 20 years) traffic needs and conditions in a manner conducive to safety, durability and economy of maintenance. Usually, the RRR project only addresses the most critical deficiencies of the highway so the resultant condition will still have some problem areas/substandard features that would be addressed as part of a future reconstruction. The agency with jurisdiction of the road may have separate design standards and procedures that apply to RRR projects.

Transportation Research Board, Special Report 214, *Designing Safer Roads, Practices for Resurfacing, Restoration, and Rehabilitation* (1987), documents the result of research on cost effectiveness of highway geometric design standards for RRR projects, and provides guidance on the overall approach for design of RRR improvements.

4.7.1.4 Reconstruction (4R)

This is an improvement alternative that rebuilds a highway essentially along the same alignment and when the retention of the pavement structure is not a primary objective. Reconstruction (the 4th R) may involve making substantial modifications to the existing highway's horizontal and vertical alignment, including alignment shifts, in order to improve safety and traffic operations.

The reconstruction work, sometimes referred to as 4R, normally involves a substantial construction effort to rebuild the existing highway to at or near full geometric/safety standards.

The complete spectrum of design deficiencies and functional obsolescence of the roadway, as well as future transportation needs, should be addressed by this level of upgrading. Typical work includes widening, realignment and replacement of bridges. While reconstruction, by nature, follows an existing road corridor, it may deviate significantly in width and alignment from the present road to obtain its full geometric standards.

4.7.1.5 New Construction

This is an improvement alternative to build a road and/or bridge on completely new alignment or substantially upgrade a highway facility along an existing alignment providing new access to or through an area. This might take the form of a bypass constructed to carry through traffic around a town or it might be a new access route linking an existing highway with a new recreational facility.

Typically, the highway is built on new alignment in a virgin corridor. It normally is constructed to full geometric standards to fulfill both the current as well as long-term transportation needs of the area.

4.7.2 CONTEXT SENSITIVE SOLUTIONS (CSS) APPROACHES

Context sensitive solutions (CSS) is a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. CSS is an approach that considers the total context within which a transportation improvement project will exist. Although the approach may be associated with flexibility in design, it involves the full range of activities from the early planning through design, construction and maintenance, and includes broad solutions involving every discipline. CSS applies to any and all projects and types of roads (i.e., every project has a unique context as defined by the terrain, the community, users and the surrounding land use). The approach includes both the outcome (qualities of the project) and the process by which it is achieved. The following are essential aspects to a successful CSS project:

- satisfies the purpose and need as developed by all stakeholders;
- effective decision-making and implementation;
- outcome reflects community values, is in harmony with the community, and is designed and built with minimal disruption;
- sensitive to environmental resources and preserves their values;
- solutions are safe and financially feasible;
- involve efficient and effective use of everyone's resources (time, budget, effort);
- exceeds the expectations of designers and stakeholders, and achieves a level of excellence in people's minds; and
- is seen as adding lasting value to the community.

Each of the various phases of the project delivery include the active engagement and collaboration of stakeholders and technical specialists, open discussion, creativity, respect for a diversity of perspectives and effective weighing of choices to implement an appropriate solution.

Refer to NCHRP Report 480, *A Guide to Best Practices for Achieving Context Sensitive Solutions* for guidance on CSS, and the CSS website.

4.7.3 DEVELOPMENT OF PRELIMINARY ENGINEERING CONCEPTS

Following the development of the Evaluation Framework and the proposed action, some elements of the preliminary engineering phase may have been modified since the completion of the project scoping report. At the onset of the preliminary engineering, clearly define the project, the design standards to be followed and the requirements for each functional classification. This is the final scope for developing the various alternatives to be considered to meet the project objectives.

Develop the design features for each viable alternative under consideration during the preliminary design phase to a similar level of detail.

4.7.3.1 Horizontal Alignment Objectives

Establish an alignment consisting of a series of circular curves that best fit the primary control points, as well as the terrain horizontal controls described in Chapter 9, Section 9.3. Conform to the guidelines for horizontal alignment described in Chapter 9, Sections 9.3.3 and 9.3.5. Connect the circular curves with tangent lines to form the preliminary alignment, using spiral transition curves where practical, particularly for 55 km/h to 90 km/h (35 mph to 55 mph) design speeds and in areas with sharp curves. Determine the superelevation runoff lengths and check that tangent lengths are sufficient to accommodate superelevation transitions. Determine the appropriate length of spiral curve transitions and add spiral transition curves between the circular curves and tangents when practical.

4.7.3.2 Vertical Alignment Objectives

Establish the vertical control points and establish a profile grade to fit these control points and adhering to the standards for percent of grade and vertical curve length. Use the following guidelines:

- Provide a smooth grade line with gradual changes, consistent with the type of highway and character of terrain. Avoid numerous breaks and short grade lengths.
- Avoid hidden dips. Hidden dips are hazardous on two-lane highways. They can hide approaching or slow moving vehicles or obstructions on the road ahead while deceiving the driver into believing that it is safe to pass or travel at high speed. Use consistent grades or introduce horizontal curves in conjunction with vertical curves to coordinate the alignment.
- Evaluate long, sustained steep grades of 800 m (0.5 mi) or more which affect traffic operation. If traffic volume is high, a slow moving vehicle lane or turnout requires study. On long downgrades, consider a truck escape ramp. On some steep grades, especially on low-speed roads, it may be desirable to break a sustained grade by making it steeper at the bottom and flatter at the top. Short intervals of flatter grade, combined with passing sight distance, permit high-powered vehicles to accelerate and pass underpowered vehicles.
- On switch-back curves, flatten the grade to facilitate speed reduction and vehicle operation at slower speeds.
- Avoid broken-back grade lines. Two vertical curves in the same direction separated by short tangents is poor design practice particularly in sags where both curves are visible at the same time.
- Sag vertical curves at the ends of long tangents should be several times the length required for stopping sight distance to avoid the appearance of an abrupt change in grade.
- When at-grade intersections occur on roadways with moderate to steep grades, it is recommended to reduce the grade through the intersection to less than 6 percent (4 percent or less desired).

4.7.3.3 Aesthetic Considerations of Horizontal and Vertical Alignment

To ensure aesthetics in highway design, accomplish the following:

- If practical, direct the highway toward scenic features, and provide curvilinear alignment through generally scenic terrain.
- If practical, locate the highway so that scenic features are large (e.g., mountains, lakes) and directly ahead of the driver’s line of vision.

- Make maximum use of independent horizontal and vertical alignment on divided highways to better blend the roadways into the terrain, provide a variable terrain buffer between the directions of travel, and reduce the visible construction scars.
- Coordinate vertical and horizontal curvature. The best appearance is achieved when vertical and horizontal curves coincide, or horizontal curvature leads vertical curvature slightly.
- Avoid short, abrupt horizontal and vertical curves, especially if the central angle is small and a substantial length of both tangents is visible.
- Avoid long horizontal tangents with vertical curves in rolling country. Roller coaster profiles are visually distressing and may create hidden dips that are misleading for passing on two-lane roads.
- Develop the preliminary design to designate sufficient right-of-way area on the inside of curves, and at the ends of long tangents, to facilitate adequate clearing and/or setback of potential future buildings or structures that could possibly impair perspective or sight distance, especially in scenic terrain.

4.7.4 DESCRIPTION OF THE ALTERNATIVES

Provide a detailed description of each alternative that was considered, whether it is carried forward for final consideration or not. The alignments and the impacts of each alternative should be fully described including specifics on why the improvement option was considered.

Exhibit 4.4-A is an example of how to show and describe an alternative and its preliminary design standards. This information should also be supplemented with a map depicting the location of the alternative as discussed in Section 4.7.5. When comparing numerous alternatives, it can also be effective to display them together in a conceptual setting.

If during development of a concept or idea, an option does not appear to best meet the goals and objectives of the project, document the reasons why the alternative was not carried forward so that if, in the future, others may consider this option during final design they will have the benefit of this evaluation and effort. It is of great benefit to those that may work on the final design to know all of the options and constraints that were considered, and not just the benefit of the recommended solution.

4.7.5 ALTERNATIVE BENEFITS AND CONSEQUENCES

The transportation related benefits and consequences of each alternative considered should be discussed in the summary report. A suggested method of evaluation is to compare each alternative relative to its fulfillment of the project's transportation related goals and objectives. As a means of comparison, each alternative may be evaluated for its transportation related benefits and consequences, as applicable:

- safety performance,
- capacity,

- traffic operations,
- level-of-service,
- accommodation of pedestrian and bicycle use,
- life-cycle cost,
- construction time,
- traffic management,
- structures and drainage,
- earthwork volumes,
- geotechnical hazards,
- right-of-way acquisition,
- utility relocation,
- maintenance requirements,
- design exceptions, and
- risk assessment for delivery and/or service.

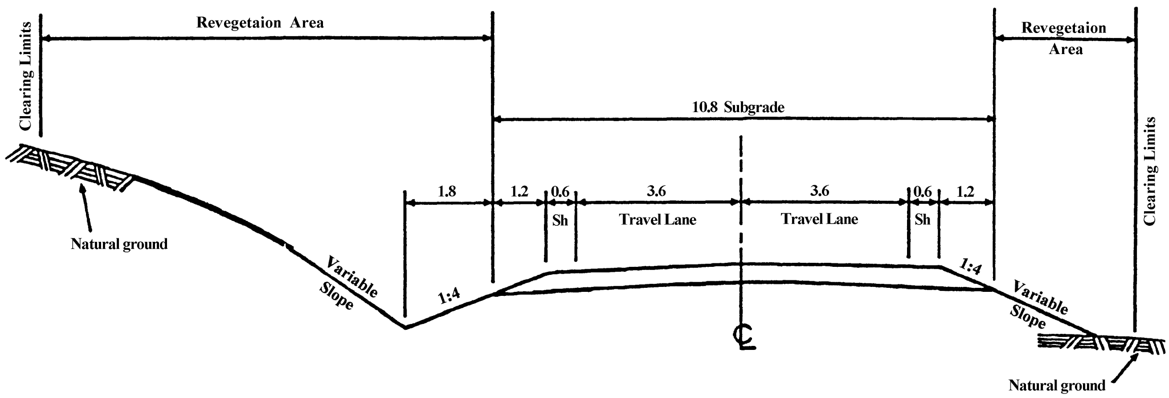
A matrix chart may be prepared to show the results of the evaluation and comparison of the alternatives. A weighting may be assigned to each type of benefit or consequence to indicate its relative importance in the evaluation. The benefits and consequences for each alternative may then be scored and tabulated so one alternative can be directly compared to another. The criteria and weighting used to assess fulfillment of the objectives in assigning scores to the different benefits and consequences should be developed with collaboration, understanding and agreement of the agency stakeholders prior to beginning the alternatives comparison, and fully explained to stakeholders at the completion of the evaluation.

4.7.6 ALTERNATIVE EVALUATION AND RECOMMENDATIONS

After all of the conceptual and preliminary engineering analysis is complete, one alternative will be identified as the preferred or recommended solution from a transportation standpoint. For the recommended alternative, explain all of the reasons and logic used to recommend this improvement over the other alternatives considered. This should be a succinct, clear representation of the how the improvements included with this alternative meet the transportation related goals and objectives of the project's purpose and need. This information will typically be used as part of the environmental process and for incorporation within the decision document.

The comprehensive evaluation of the alternatives developed for meeting the project purpose and need, including all the goals and objectives of the project, is addressed in the environmental process and decision document as described in Chapter 3.

Exhibit 4.7-A presents an example of a typical presentation of an alternative.



ALTERNATIVE A

Note: This alternative for the reconstruction of 105 km (65 mi) of Flat Mountain Road by widening and adding bituminous surfacing to obtain a 8.4-m (27.5-ft) wide roadway consisting of two 3.6-m (12-ft) paved lanes and two 0.6-m (2-ft) paved shoulders. Roadside features such as 1V:4H foreslopes, variable ditch widths and backslopes with minimum selective clearing are included to provide a reduced, but adequate cross section with standard sight distances and roadside safety.

The horizontal and vertical alignment of the existing road will be adjusted by curve flattening, grade raises and short relocations to provide a minimum 60 km/h (40 mph) design speed. Necessary widening will be provided with the least effect on natural features and private property. Generally, widening will be made on the roadside away from the river or other sensitive features (e.g., wetlands).

The bridge over Deep Creek at km 20.1 (mi 12.9) is to be replaced in approximately the same location. The existing right-of-way can be used in constructing much of this alternative. Partial takings from parcels along the existing roadway totaling approximately 0.93 ha (2.3 ac) will be required for widening, improving the site distance and reducing the severity of curves.

The proposed improvement of FH 72 begins at km 20.8 (mi 12.9), which is the northern terminus of previous improvements and generally follows the existing road to the vicinity of Dutch Road, about km 20.4 (mi 12.7). At this point, an alignment shift is proposed 60± m (200 ft) to the east of the existing road. This approximately 600-m (2000-ft) long relocation would avoid a congested area formed by residences and commercial property bordering the east side of the existing road and a historic mine site bordering the west side. The proposed improvement connects with the existing road at about km 20.9 (mi 12.9) and generally follows it northerly to its terminus at an intersection with US 22 (km 30.2 (mi 18.7)).

Exhibit 4.7-A TYPICAL PRESENTATION OF AN ALTERNATIVE

4.8 DESIGN FEATURES OF THE PROPOSED IMPROVEMENTS

Once the recommended improvement has been identified, a clear and succinct summary of the known and unknown design parameters should be outlined as part of the preliminary design. This information will be used as the controlling design information as the project moves from a study perspective to a final design perspective.

This design information is also needed to quantify environmental impacts and assess compliance with numerous environmental laws (Chapter 3, Section 3.3). Specific design and engineering information is needed to support the environmental process and ultimately a NEPA decision. A primary objective of this section is to identify the discipline specific information that is needed to support the basis for that decision.

Refer to Exhibit 4.1-A for a flow chart of the overall project development process. In the flow chart, the activity shown as Preliminary Engineering is the primary subject of this Section.

4.8.1 GEOMETRIC DESIGN ELEMENTS

Summarize the complete consideration of the geometric design controls proposed for the recommended improvement. These may be identical to those controls listed in Section 4.4.4 of this chapter, but if any adjustments were necessary during the alternatives investigation, they should be clearly defined for the final design team to use during the completion of the final design.

4.8.1.1 Design Speed

Establish the design speed to be used for each type of facility to be designed (e.g., mainline, intersecting collectors, frontage/access roads, turnouts). If there are changes in the design speed due to changes in topography or capacity of the facility, describe where the changes occur and why these changes were necessary.

4.8.1.2 Typical Section

Develop a full representation of the cross section elements of the final design. For each roadway section, develop the number of lanes, lane widths, shoulder widths, foreslope widths and slope, the conceptual design of the medians, ditches, curb and gutter requirements, etc. If lane widening is required for turning movements, develop the lanes, shoulders and slopes adjacent to these facilities as well.

4.8.1.3 Slope Selection

Develop the cut and fill slope selection criteria, if other than provided in Chapter 9, Exhibit 9.5-A. The general slope requirements of the roadway section are described in the typical section. If there are special slopes required due to variations in the materials or for rockfall mitigation, provide these criteria.

4.8.1.4 Superelevation

Determine the normal crown and maximum superelevation of the roadway and curves. Determine if maximum superelevation rates should vary, according to the elevation or climatic conditions on the project. Define the methodology for distribution of superelevation on the curve and on the tangent, and what the maximum and minimum rates are for various conditions. Determine if spirals should be used in the horizontal alignment.

4.8.1.5 Horizontal and Vertical Controls

Develop an alignment fulfilling the horizontal alignment objectives of Section 4.7.3.1. For the horizontal alignment, establish the minimum radius to be used for each design speed and roadway section, and the requirements for stopping and passing sight distance. Determine if there are horizontal clearance criteria constraints to be applied.

For the vertical alignment, develop an alignment fulfilling the objectives of Section 4.7.3.2. Determine the minimum and maximum gradient to be used for each design speed and roadway section. These may vary within a project as the terrain changes. If so, define where and why these changes occur. Determine the minimum vertical clearance and stopping sight distance requirements.

Document the design standards information using a form such as the example shown in Chapter 9, Form 9.1-A.

4.8.2 INTERSECTIONS

Identify the standards to be used for the intersections contained within the project. Determine and provide a description of the design vehicle that will use the intersection, and the minimum radius of the outside and inside radius returns.

If there are known constraints that preclude obtaining the desired intersection sight distance, provide guidance on how to mitigate this safety concern.

4.8.3 RAILROAD-HIGHWAY CROSSINGS

Define the scope of improvements to the crossing by conducting an on-ground joint inspection of the site with railroad engineering staff, the State or highway operating agency and other interested parties before starting the survey or design.

If possible, obtain a recent railroad map of the site indicating railroad right-of-way for the meeting.

This review should clarify other railroad company policies on these topics:

- the closest encroachment to the centerline of tracks permitted,
- sight distance triangles,

- traffic maintenance (detours),
- drainage, bank protection or other conditions to be encountered on the proposed highway location, and
- railroad work schedules.

Before designing improvements in the vicinity of existing crossings or new crossings, arrange for a field inspection of the crossing site. The review should involve appropriate Federal, State, local and railroad representatives. Even if no improvements are made to the railroad crossing, coordination is needed early with the railroad company in regard to temporary traffic control that may affect the railroad. These special considerations and coordination should also be clearly stated in the Temporary Traffic Control Plan and in the SCRs.

The review should resolve financial responsibility, scheduling and authorization to proceed with the work. The type, number and location or railroad signals to be installed should also be determined.

All utilities, both aerial and buried, in possible conflict with the proposed installation must be noted, including facilities interfering with the proposed railroad signals or gate installations requiring adjustments. In some instances, it may be preferable to adjust the location of the railroad signals. Consider any proposed future highway widening project when determining placement of the signals.

Photographs taken during a field inspection are very helpful during the design phase of the project.

4.8.4 DRAINAGE

Develop the conceptual drainage design to be applied for the drainage watersheds where the project is located.

Determine the scope of any apparent existing drainage problems or needed improvements based on field observations, previous safety reports or discussions with the roadway maintenance staff. Determine if there are any special measures required for erosion control or improvements to existing inlets/outlets that must occur. Also, determine any roadway profile issues that may need to be addressed during the final design (e.g., insufficient clearance over proposed culverts or adjustments in the roadway design or drainage facilities to prevent roadway flooding or overtopping).

Assess the potential impacts or encroachments into floodplains and floodways, coastal waterways and fisheries and streams. Determine the scope of any channel migration concerns and any anticipated stabilization work that may be necessary. If there are potential embankments or retaining walls required adjacent to streams/channels, they should be evaluated. If there are any active waters that must be crossed during construction, access across these features should be investigated including low-water crossings and temporary structures for construction activities. For any bridges over waterways, any scour and flow capacity issues must be addressed as part of the preliminary engineering study.

4.8.4.1 Hydrology and Hydraulic Guidelines

Determine the standards and guidelines that are to be used for evaluating and designing the drainage improvements. These are defined more clearly in Chapter 7.

4.8.4.2 Floodplain Considerations

Determine the limits of any floodplains either within or nearby the project that are regulated. If there are known encroachments into these waterways by the recommended improvements, evaluate the potential effects and whether these encroachments could or could not be avoided and how they can be mitigated.

If a change in the floodplain is required, develop the procedures for working with the local jurisdictional agency to submit and complete these changes.

4.8.5 GEOTECHNICAL

Determine the results of the evaluation performed under Section 4.5.2.11.7.

Determine the scope of follow-up investigations that are still necessary which will be conducted later in the preliminary design process as described in Chapter 6, Section 6.3.

4.8.6 PAVEMENTS

Determine the results of the evaluation performed under Section 4.5.2.11.8. For conceptual design, the depth of the pavement structure may be an assumption based on past experience or by comparing with the depths used on an adjacent project. If this is used, provide the basis of where this information was obtained.

4.8.7 STRUCTURES

Determine the results of the evaluation performed under Section 4.5.2.11.10.

4.8.8 RIGHT-OF-WAY

Identify the existing right-of-way corridor and roughly approximate the proposed right-of-way area. Describe the property affected and the nature of impacts. Estimate the approximate right-of-way cost and any special right-of-way problems. If all or part of the route crosses public lands, identify the agency controlling the land.

4.8.9 ACCESS MANAGEMENT

Refer to evaluation of access management issues as described in Chapter 8. Consider the following issues:

- operational effects,
- safety effects,
- design considerations, and
- right-of-way considerations.

4.8.10 UTILITIES

Provide the results of the evaluation performed under Section 4.5.2.12.5.

4.8.11 PERMITS

Incorporate into the preliminary design the features that will be provided for any permit applications, and anticipated requirements of any necessary permits described under Section 4.5.2.12.6.

4.8.12 CONSTRUCTION CONSIDERATIONS

Construction considerations include the sequencing of the work and its constructability. Refer to Chapter 9, Section 9.6.2.

4.8.13 ENVIRONMENTAL FEATURES AND CONCERNS

Incorporate into the preliminary design the environmental, public and context sensitive issues, concerns and opportunities addressed in Section 4.6. If any of these objectives could not be achieved during the development of the preliminary design of alternatives, explain why these objectives presented such a challenge and what mitigation efforts should be considered.

4.8.14 DESIGN EXCEPTIONS

Evaluate any features of the preliminary design that do not conform to current approved standards. Refer to Chapter 9, Section 9.1.3 for preparation of design exceptions.

4.8.15 COST ESTIMATES

Develop a construction cost estimate for the project. The following provides guidance on three types of estimates:

1. **Class A Estimate**. A Class A estimate is based on unit prices and bid items quantities. A Class A Estimate is not typically prepared until the 50 percent or 70 percent level of the final design phase. Refer to Chapter 9.

2. **Class B Estimate**. A Class B estimate is based on estimated quantities and unit costs for the major categories of work, and either a cost per kilometer (mile) or percentage of total construction costs for the minor categories of work. A Class B estimate may be

performed as part of the preliminary design phase if adequate design detail is developed; however, a Class C estimate is typically prepared at this stage. Cost estimates for constructing a road in the corridor are developed using quantities and unit prices for the major high-cost items. The following provides examples of major items:

- clearing and grubbing per hectare (acre);
- unclassified roadway excavation per cubic meter (cubic yard);
- minor drainage per kilometer (mile);
- surfacing and base per metric ton (ton);
- paving (type) per metric ton (ton);
- major structures per each (identify); and
- miscellaneous items as a lump sum or percentage of the total construction. Include mobilization, construction survey and staking, construction traffic control, guardrail, guide posts, fences, revegetation, landscaping, etc. Refer to Chapter 9.

3. **Class C Estimate** A Class C estimate is based on a per kilometer (mile) or cost for similar type scope of work projects. A Class C estimate may have been previously prepared during the planning or programming phase, or may have been provided by the Federal land management agency. Verify, or develop, a Class C estimate for the scope of the improvements as part of the conceptual studies and preliminary design phase.

4.9 IMPLEMENTATION

Section 4.9 addresses the determination of how the project will be designed and delivered. Topics to be addressed include how the project will be staged into multiple projects or stages if it is a long route, whether alternative delivery methods (e.g., design-build) will be used, how the PS&E is going to be developed and presented, overall final design and construction schedule, funding options, program requirements and other similar details.

4.9.1 PRELIMINARY DESIGN REVIEW

The preliminary design review covers the preliminary design and results in evaluation and resolution of the major design features for a project (e.g., horizontal and vertical alignments, typical section, access control). It typically represents the 30 percent level of design detail sufficient to support the environmental analysis, documentation and decisions. The preliminary design review typically includes both an internal review and an external (i.e., partner agencies and stakeholders) review.

The purpose of the review is to evaluate and resolve the roadway geometry, safety considerations, environmental impact mitigation and cost effectiveness of the proposed improvement. The review should also identify the revisions needed to bring the roadway design, plans and estimate to a full 30 percent stage.

The level of detail for the preliminary design review depends on the scale of proposed improvements and may be different for RRR projects than for reconstruction or new construction projects. The information available for the review (deliverables) includes detail maps or plans and profiles showing preliminary alignments and plotted cross sections of the mainline and major intersecting roadways for all alternatives being considered and preliminary construction cost estimate.

As part of the review, it is essential that the designer identifies and documents any exceptions to standards along with the associated hazards so that all parties are aware of the potential consequences of the decisions.

4.9.2 PROGRAM REQUIREMENTS

The preliminary design documents should address the FLH and program-specific requirements, expectations or guidelines for final design and project delivery that will affect the project implementation. Reference to Memorandums of Agreement where they pertain to final design and delivery should be included in the project documentation. Refer to Chapter 2 for information on the various FLH programs. In addition to the program requirements described in the following Sections, each project should be implemented in accordance with the project agreement that is developed specifically for the individual project, as described in Section 4.6.3.

4.9.2.1 Forest Highways and Public Lands Highways

For Forest Highways and Public Lands Highways, the project will be located within or provide access to National Forest or other public lands. The road-owning agency is typically the State DOT if the road is a State highway or the county or city, if the road is not a State highway. The project may involve private right of way and utilities, and will typically provide access to private lands as well as public lands. The project stakeholders will generally consist of the land management agency, the road owning agency, other cooperating and resource agencies and representatives of interest groups and the public for which the road may provide service. The project implementation should be in accordance with the Tri-agency agreement for the State in which the project is located.

4.9.2.2 National Park Roads and Parkways

National Park Roads and Parkways projects will typically be located entirely within a national park or parkway. The road-owning agency is typically the National Park Service, but may be a State DOT, a County or city in some cases. The project may involve utilities and possibly access to private properties. For Park Roads projects, a value analysis may be performed by the NPS. The designer should provide the appropriate preliminary design information as described above to the Park Service and should attend the Value Analysis meeting as requested. Refer to the NPS document, *Value Based Decision-making* for guidance on value analysis. Following the value analysis, a Development Advisory Board (DAB) review will be performed by the NPS. As part of the preliminary design activity, provide further technical support (e.g., preliminary design details, cost estimates) for this review as requested. The project implementation should be in accordance the MOU between the FHWA and the National Park Service.

4.9.2.3 Refuge Roads

Refuge Roads are public roads within a national wildlife refuge that are owned and maintained by the Federal Government, typically by the US Fish and Wildlife Service. The project may involve utilities and possibly access to private properties or other Federal lands. For refuge roads, the projects are intended to be rehabilitation or maintenance type improvements, and not major reconstruction or construction of new roads. The project implementation should be in accordance with the Interagency Agreement between the US Fish and Wildlife Service and the FHWA.

4.9.2.4 Defense Access Roads

Defense Access Roads are public highways that provide transportation services to a defense installation. This may also include public highways through military installations when right-of-way for these roads is dedicated to public use and a civil authority maintains the roads. These roads are generally owned by State or local governments and are typically not within the boundaries of military reservations, but they may be roads at military reservations or defense industry sites and may be closed to the public or restricted. There will generally be an agreement between the FHWA and the military command for the specific military roads or installations, and the project implementation should be in accordance with this agreement.

4.9.2.5 ERFO Projects

ERFO Projects are intended to repair or reconstruct Federal roads and bridges seriously damaged by a natural disaster or catastrophic failure. Due to their nature, these unplanned projects are generally very high priority and may need to be delivered using fast, non-traditional approaches. The projects may include any of the type roads described in Sections 4.9.2.1, 4.9.2.2, 4.9.2.3 and 4.9.2.4 or other type roads on Federal lands. Restoration in-kind to pre-disaster conditions is expected to be the predominant type of repair. Implementation should be in accordance with the ERFO Manual.

4.9.2.6 Special Projects

Special projects are in addition to the main FLH Program projects that are described in the above sections. A special project agreement will typically be executed between the FHWA and the partner agencies or project stakeholders. The project implementation should be in accordance with this agreement.

4.9.3 STAGE CONSTRUCTION

Limited funding may restrict the sequence of reconstruction of a highway segment. When this is the case, consider Stage Construction. This is where the grading is completed first and the paving at a later time. This assures that the basic geometrics (i.e., alignment, grades, cross section) are initially built to an established standard without need of further modification during later stages.

4.10 DOCUMENTATION

Conceptual studies and preliminary design provide findings and recommendations that are reviewed and commented on by various agencies and stakeholders. The studies are used to guide further design activities, environmental studies, field investigations, etc. This information can be documented and reported to the agencies in various ways or combined in other documents.

For the purposes of defining the series of investigations during the conceptual studies phase for Federal lands, they are defined as follows:

1. **Project Scoping Report**. The field inspections and compilation of existing engineering data used to identify and quantify a highway's deficiencies and needs are gathered and summarized in the Project Scoping Report. As part of this study, recommendations for further study will also be made in order to develop a course of action with suggestions for investigating improvement alternatives and conducting engineering analyses that result in a preferred alternative are collectively called a project scoping study. The details of this report are detailed in Section 4.5.2.

2. **Corridor Study Report**. Occasionally, it becomes apparent that a highway should be considered on new alignment in a corridor outside of the existing road. These new highway corridors are usually identified and evaluated separately from preliminary engineering alternatives although they must be compatible with all the components that make up the alternatives. A highway corridor can be defined as a linear strip of ground that connects termini and has sufficient width and variable positioning on the terrain to allow a road with its preliminary design standards to be built within its borders. This report documents the decision to develop a new corridor, or contain the improvements within the existing corridor. The details for performing this work are detailed in Section 4.5.3.5.

3. **Preliminary Engineering Study Report**. After a determination is made to evaluate specific alternatives, each option considered is developed to the same level of effort (20 to 30 percent design) for similar comparisons. The Preliminary Engineering Study Report is the final report that documents the information, investigation and evaluation made during the conceptual studies and preliminary design process, and presents the engineering results of a recommended alternative for final design. The details for performing this work are detailed in Section 4.10.1.

Since the results of the conceptual studies and preliminary engineering analysis provide the critical engineering and/or reconnaissance information, array of alternatives and, in some cases, form the preferred alternative to be contained in the environmental document, these findings should be reviewed and concurred with by the appropriate Division staff who are responsible for the clearance of environmental documents. In addition, land management agencies should also review and concur in the engineering findings regardless of whether they have been documented by informal analyses or in a comprehensive, formal Preliminary Engineering Study Report. This will ensure the environmental process is evaluating alternatives that the land management agency is comfortable with. Concurrence of the report or informal findings does not constitute approval of a specific alternative or issue authority to commence final design activities.

4.10.1 PRELIMINARY ENGINEERING STUDY REPORT

The results of the conceptual studies and preliminary engineering analysis of the conceptual design should be documented in a Preliminary Engineering Study Report (e.g., design scoping report, project identification report). As a minimum, the findings and recommendations should be documented by a standardized form or checklist that addresses the applicability of each of the listed items and a description of existing features, design controls, proposed design standards and scope of the engineering work needed to deliver the project. Memorandums, trip reports or semi-formal checklists can be used to support the Preliminary Engineering Study Report. In any case, this information must be documented to ensure the findings and/or recommendations, as well as existing conditions can be reviewed and understood by all interested and affected parties. The report should be retained and readily retrievable until the final design is completed. All improvement alternatives should be readily supportable from an engineering position, which is contained in these study documents.

The final study report should contain the following items:

1. **Summary.** This will be a brief summary of the project's location, limits, route number, a brief summary of the project's scope, a summary of alternatives investigated and the description and cost of the preferred alternative. It should also describe any inter-agency agreements that have been made to complete the project.

2. **Introduction**. Describe the authority, the purpose and need for the project, ownership and maintenance, project objectives, brief history and a full description of the project. It should include:

   - length of the project,
   - termini of the project,
   - functional classification,
   - typical section of the project,
   - number of lanes,
   - existing intersections,
   - existing site conditions,
   - safety upgrades proposed,
   - drainage improvements proposed,
   - structure improvements proposed,
   - utility issues,
   - traffic control issues, and
   - right-of-way constraints.

3. **Resources Used.** Identify all sources of information, input, maps and data obtained for the study.

4. **Climate, Physiography and Geology**. Provide a description of the climate, significant geographic features, land uses and geology of the area.

5. **Summary of Traffic and Crash Data**. Provide a summary of all of the traffic and crash data obtained for the project.

6. **Summary of Controlling Design Criteria**. This section will describe the applicability of design standards, any non-conforming design elements of the existing facility that will be upgraded as part of the project and those elements for which design exceptions will be required.

7. **Location Analysis**. For those projects where a corridor study (see Section 4.5.3) is included, also include a location analysis.

8. **Design Concepts Alternatives.** This section will include a description of those alternatives considered and discontinued, those studied in full, an evaluation of the studied alternatives and conclusions/recommendations for the final improvement. Design concepts and recommendations should be described for distinct segments of the route that have varying characteristics.

9. **Major Design Features of the Recommended Alternative**. Include descriptions of the major design features of the recommended alternative, which includes:

   - design controls;
   - horizontal and vertical alignments;
   - intersections;
   - drainage;
   - geotechnical including earthwork balance and issues;
   - pavements;
   - structures;
   - constructibility and traffic control;
   - intersections;
   - utilities;
   - right-of-way;
   - access management, including operational effects of access management and the safety effects of access management;
   - utilities;
   - permits;
   - constructibility and staged construction (implementation); and
   - design exceptions.

See Section 9.3 for further information on geometric design.

10. **Cost Estimates**. Include a Class C or B cost estimate as appropriate. See Section 4.8.15.

11. **Construction Phasing or Scheduling**. Where a project includes construction phasing, include a description of each of the phases. Also, include a description of the construction schedule for all projects.

12. **Social, Economic and Environmental (SEE) Concerns**. Address any concerns or issues regarding the social, economic and environmental aspects of the project. See Chapter 3 for detailed information on the environmental process.

13. **Exhibits**. Examples of exhibits include:

    - Typical Sections,
    - Project Vicinity and Location Maps, and
    - Plan/Profile Exhibits of Alternatives.

4.10.2 ENVIRONMENTAL DOCUMENT

At the conclusion of conceptual studies and preliminary design, a decision must be made identifying which alternative is going to be advanced into the design phase. The decision-making process is described in Chapter 3.

The engineering information and descriptions of the improvement alternatives contained in the environmental documents are summarized from the conceptual studies and preliminary design. Since the final decisions are a product of the environmental process, it is imperative that environmental documents present the engineering data in an accurate, complete and understandable fashion. Close and continuous collaboration between the preliminary design and the environmental analysis and documentation is essential. The content of environmental documents are described in Chapter 3.

4.10.3 DEVELOPMENT REQUIRED FOR FINAL PS&E

Formal selection of the preferred alternative occurs when the project's environmental clearance document is approved as described in Chapter 3, Section 3.5. This also completes the conceptual study and preliminary design phase and advances the project into the final design phase and subsequent plans, specifications and estimates (PS&E) preparation.

The description of the selected alternative that is contained in the environmental decision making documents (e.g., categorical exclusion, finding of no significant impact, record of decision) should include preliminary design standards and corridor engineering information in sufficient detail to ensure the project will be designed to implement the approved concept.

4.11 DIVISION SUPPLEMENTS

Reserved for Federal Lands Highway Division office used in supplementing policy and guidelines set forth in this Chapter with appropriate Division procedures and direction.

4.11.1 EFLHD SUPPLEMENTS

Refer to the EFLH Division Supplements.

4.11.2 CFLHD SUPPLEMENTS

Refer to the CFLH Division Supplements.

4.11.3 WFLHD SUPPLEMENTS

Refer to the WFLH Division Supplements.